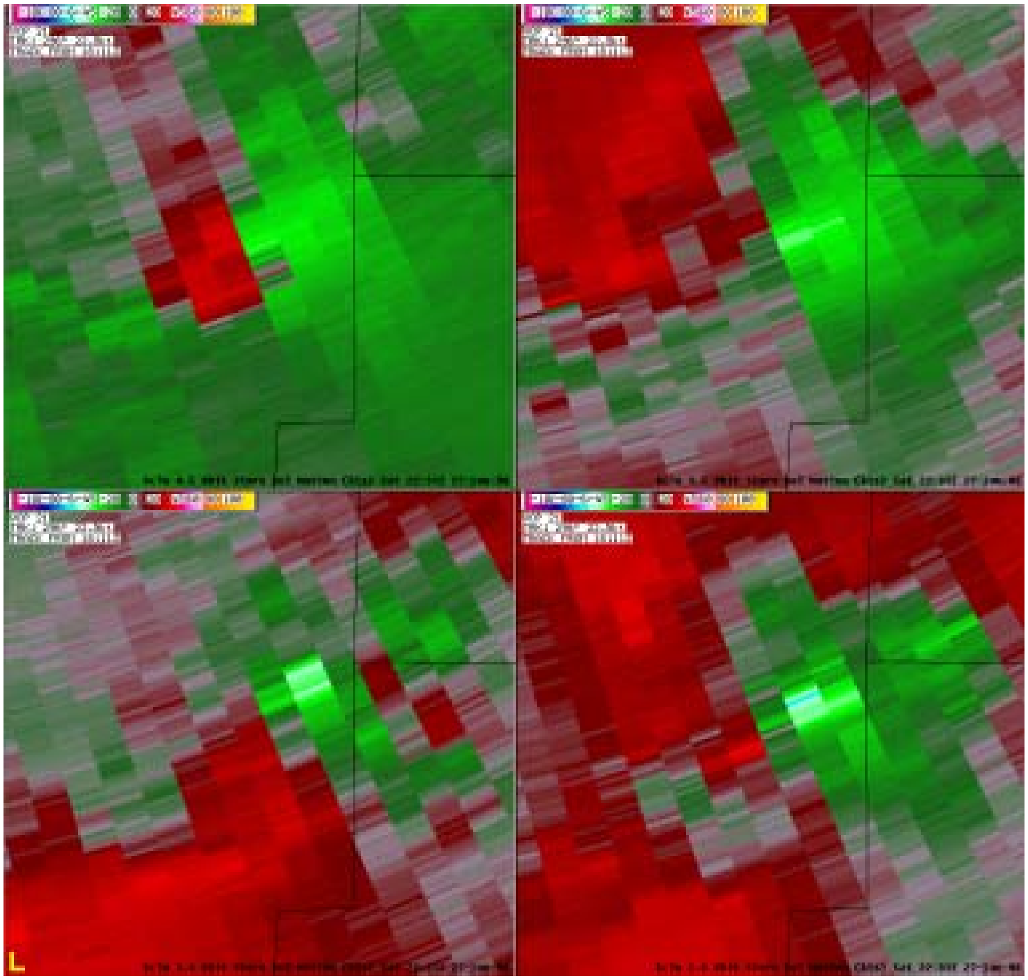
Distance Learning Operations Course



IC 5.5 WSR-88D Derived Products

Presented by

The Warning Decision Training Branch

Version: 0308

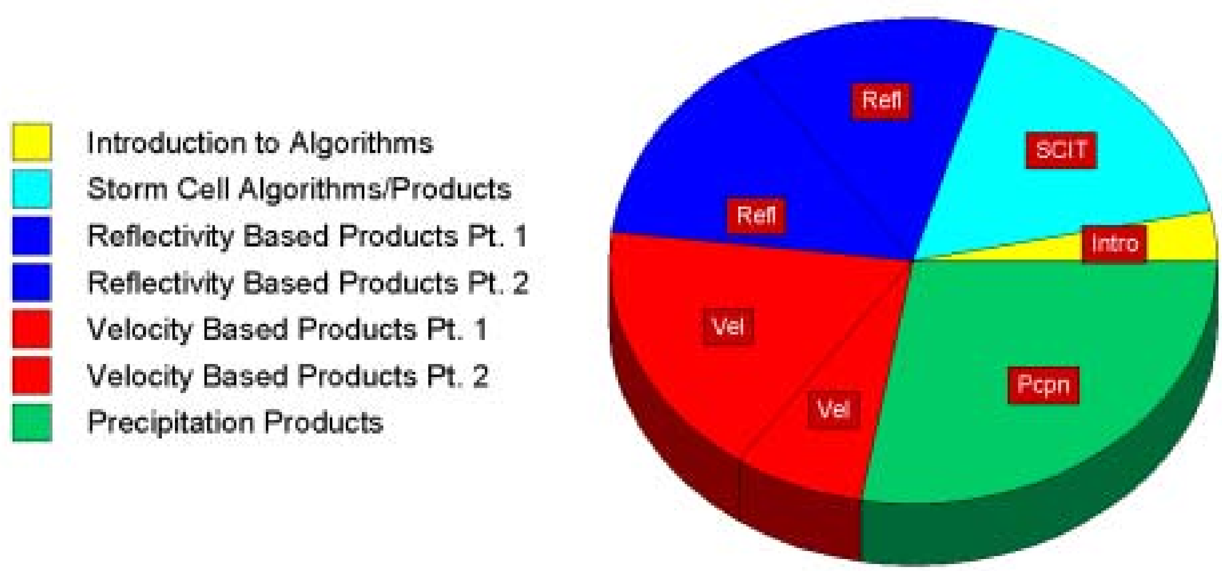
Table of Contents

Preface

Overview

Welcome to *WSR-88D Derived Products*! This Student Guide is to be used during the *WSR-88D Derived Products* teletraining session*.* You should place this in your DLOC student binder. This Student Guide not only contains materials presented in the teletraining presentations, but also practice exercises, and supplemental materials. To most effectively learn the material, it is strongly suggested that after attending teletraining, you do the worksheets and exercises in this Student Guide. When answering the questions, you may then choose to review this Student Guide.

Before taking Exam 3, you should be comfortable with the objectives listed in each of the six lessons of this Student Guide as well as the answers to review exercises. Worksheets are also provided for those who want a little extra practice.



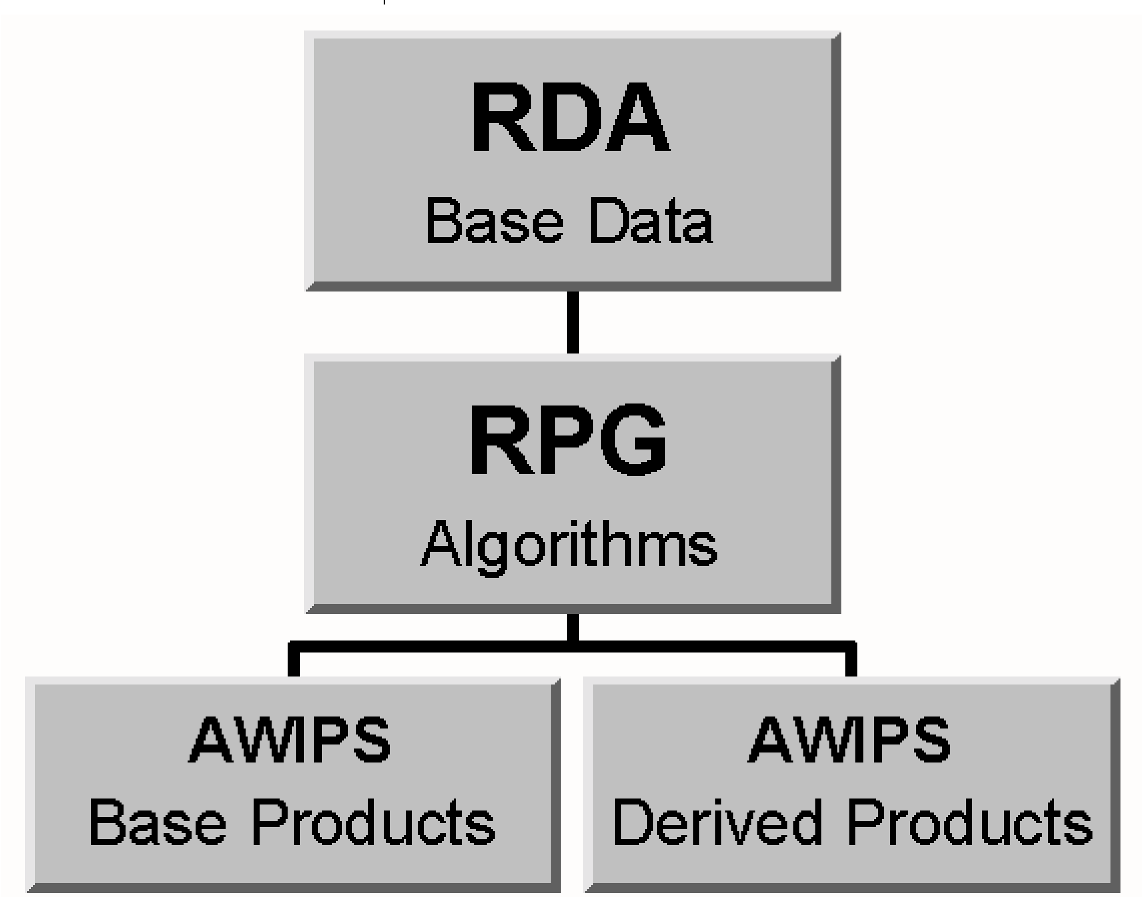
Objective

1. Interpret all derived products of the WSR-88D, including:

a. Specific characteristics of Derived Products,

b. Strengths and limitations of Derived Products,

c. Specific operational applications of Derived Products.



PRODUCTS	Product ID #	Spatial Resolution nm	X nm or deg	Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions) Radius (nm)	nm X nm	Load-shed Priority #	Saved on Archive Level 3 Modes: A	B	RPCCDS Products Modes: A	B	NAPUPS Modes: A	B
Base Reflectivity (R)	16	0.54	1 deg.	8	124	124	------	56	---	---	---	---	---	---
	17	1.1	1 deg.	8	248	248	------	55	---	---	---	---	---	---
	18	2.2	1 deg.	8	248	248	------	54	---	---	---	---	---	Y"
	19	0.54	1 deg.	16	124	124	------	89	Y"	Y"	Y*	Y*	Y*	Y*
	20	1.1	1 deg.	16	248	248	------	88	Y"	---	Y"	---	Y"	---
	21	2.2	1 deg.	16	248	248	------	87	---	---	---	---	---	---
Mean Radial Velocity (V)	22	0.13	1 deg.	8	32	32	------	53	---	---	---	---	---	---
	23	0.27	1 deg.	8	62	62	------	52	---	---	---	---	---	---
	24	0.54	1 deg.	8	124	124	------	51	---	---	---	---	---	---
	25	0.13	1 deg.	16	32	32	------	86	Y"	Y"	Y"	Y"	Y"	Y"
	26	0.27	1 deg.	16	62	62	------	85	---	---	---	---	---	Y^
	27	0.54	1 deg.	16	124	124	------	84	Y"	Y"	Y*	Y*	Y*	Y*
Spectrum Width (SW)	28	0.13	1 deg.	8	32	32	------	60	Y"	Y"	Y"	Y"	Y"	Y"
	29	0.27	1 deg.	8	62	62	------	59	---	---	---	---	---	Y^
	30	0.54	1 deg.	8	124	124	------	58	Y"	Y"	Y"	Y"	Y*	Y*
User Selectable Precip (USP)	31	1.1	1 deg.	16	124	124	------	57	---	---	---	---	Y	Y
Digital Hybrid Reflectivity (DHR)	32	0.54	1 deg.	256	248	248	------	57	---	---	---	---	---	---
Hybrid Scan Reflectivity (HSR)	33	0.54	1 deg.	16	124	124	------	57	---	---	---	---	Y	Y
Clutter Filter Control (CFC)	34	0.54	1.4 deg.	8	124	124	------	99	Y	Y	Y	Y	Y	Y
Composite Reflectivity (CR)	35	0.54	0.54	8	124	124	------	48	---	---	---	---	---	---
	36	2.2	2.2	8	248	248	------	47	---	Y3	---	Y	---	Y
	37	0.54	0.54	16	124	124	------	76	---	---	Y	Y	---	---
	38	2.2	2.2	16	248	248	------	75	Y3	Y3	Y	Y	Y	Y
Echo Tops (ET)	41	2.2	2.2	16	124	124	------	66	Y3	---	Y	---	Y	---

" = Lowest Tilt ; ~ = Lowest 2 Tilts ; ^ = Lowest 3 Tilits ; * = Lowest 4 tilts
3 = Every Third Volume Scans ; 6 = Every Sixth Volume Scans

PRODUCTS	Product ID #	Spatial Resolution nm X	nm or deg	Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions) Radius (nm)	nm X nm	Load-shed Priority #	Saved on Archive Level 3 Modes: A	B	RPCCDS Products Modes: A	B	NAPUPS Modes: A	B
Severe Weather Analysis (SWA)														
(SWR) Reflectivity	43	0.54	1 deg.	16	124	----	27 x 27	94	---	---	---	---	---	---
(SWV) Velocity	44	0.13	1 deg.	16	124	----	27 x 27	93	---	---	---	---	---	---
(SWW) Spectrum Width	45	0.13	1 deg.	8	124	----	27 x 27	92	---	---	---	---	---	---
(SWS) Radial Shear	46	0.27	1 deg.	16	124	----	27 x 27	46	---	---	---	---	---	---
Severe Weather Probability (SWP)	47	15.4	15.4	N/A	124	124	------	69	Y	---	---	---	Y	---
Velocity Azimuth Display Profile (VWP)	48	N/A	N/A	5	Default 16	----	------	82	Y6	Y6	Y	Y	Y	Y
Reflectivity Cross Section (RCS)	50	0.54	0.27vertical	16	124	----	------	98	---	---	---	---	---	---
Velocity Cross Section (VCS)	51	0.54	0.27vertical	16	124	----	------	97	---	---	---	---	---	---
Storm-Relative Mean Radial Velocity Region (SRR)	55	0.27	1 deg.	16	124	----	27 x 27	67	---	---	---	---	---	---
Storm-Relative Mean Radial Velocity Map (SRM)	56	0.54	1 deg.	16	124	124	------	68	Y"	---	Y"	---	Y~	---
Vertically Integrated Liquid (VIL)	57	2.2	2.2	16	124	124	------	83	Y	---	Y	---	Y	---
Storm Tracking Information (STI)	58	N/A	N/A	N/A	248	248	------	74	Y	---	Y	---	Y	---
Hail Index (HI)	59	N/A	N/A	5	124	124	------	72	Y	---	Y	---	Y	---
Mesocyclone (M)	60	N/A	N/A	3	124	124	------	71	Y	---	Y	---	Y	---
Tornadic Vortex Signature (TVS)	61	N/A	N/A	2	124	124	------	70	Y	---	Y	---	Y	---
Storm Structure (SS)	62	N/A	N/A	N/A	248	248	------	73	Y3	---	Y	---	Y	---
Layer Composite Reflectivity Average (LRA)	63,64,89	2.2	2.2	8	-51	----	248 x 248	42,42,10	---	---	---	---	---	---
Layer Composite Reflectivity Maximum (LRM)	65,66,90	2.2	2.2	8	-51	----	248 x 248	63,62,61	---	---	Y	Y	Y	---

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PRODUCTS	Product ID #	Spatial Resolution nm	X nm or deg	Number of Data Levels Available	MAX Range of Product (nm)	Product Coverage (Dimensions) Radius (nm)	nm X nm	Load-shed Priority #	Saved on Archive Level 3 Modes: A	B	RPCCDS Products Modes: A	B	NAPUPS Modes: A	B
LRM AP Removed (APR)	67	2.2	2.2	8	124 - 175	----	248 x 248	62	---	---	Y	Y	---	---
Use Alert Message (UAM)	73	N/A	N/A	N/A	N/A	N/A	----	91	----	----	----	----	----	----
Radar Coded Message (RCM)	74	Approx 5 (1/16 LFM)	Approx 5 (1/16 LFM)	9	248	248	------	65	Y	Y	Y	Y	Y	Y
Free Text Message (FTM)	75	N/A	N/A	N/A	N/A	N/A	----	91	----	----	Y	Y	----	----
One Hour Precipitation (OHP)	78	1.1	1 deg.	16	124	124	------	81	Y3	---	Y	---	Y	Y
Three Hour Precipitation (THP)	79	1.1	1 deg.	16	124	124	------	77	---	---	Y	---	Y	Y
Storm Total Precipitation (STP)	80	1.1	1 deg.	16	124	124	------	78	Y3	---	Y	---	Y	Y
Digital Precipitation Array (DPA)	81	Approx 5 (1/40 LFM)	Approx 5 (1/40 LFM)	256	124	124	------	80	Y	Y	Y	---	Y	Y
Supplemental Precipitation Data (SPD)	82	N/A	N/A	N/A	124	----	------	79	Y	Y	Y	---	Y ---	Y ---
Velocity Azimuth Display (VAD)	84	N/A	N/A	8	0.54 - 124	----	------	57	---	---	---	---	---	---
Reflectivity Cross Section (RCS)	85	0.54	0.27vertical	8	124	----	------	50	---	---	---	---	---	---
Velocity Cross Section (VCS)	86	0.54	0.27vertical	8	124	----	------	49	---	---	---	---	---	---
Combined Shear(CS)	87	0.27 to 2.2	1 deg.	16	124	----	124 x 124	39	---	---	---	---	---	---
ITWS Digital Base Velocity (DBV)	93	0.54	1 deg	256	62	62	------	87	---	---	---	---	---	---
Base Reflectivity Data Array (DR)	94	0.54	1 deg	256	248	248	------	35	---	---	---	---	---	---
Base Velocity Data Array (DV)	99	0.13	1 deg	256	124	124	------	34	---	---	---	---	---	---
Clutter Likelihood Reflectivity (CLR)	132	0.54	1 deg	11	124	124	------	87	---	---	---	---	---	---
Clutter Likelihood Doppler (CLD)	133	0.54	1 deg	12	124	124	------	87	---	---	---	---	---	---
Hi Res Digital VIL (DVL)	134	0.54	1 deg	256	248	248	------	80	---	---	---	---	---	---
Super Ob (SO)	136	NA	NA	NA	NA	NA	------	89	---	---	---	---	---	---
User Selectable Layer Reflecticity (USR)	137	0.54	0.54	16	124-175	----	248 x 248	65	---	---	---	---	---	---
Digital Storm Total Precipitation (DSP)	138	1.1	1 deg	256	124	124	------	80	---	---	---	---	---	---

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Lesson 1: Introduction to Meteorological Algorithms

WSR-88D Meteorological Algorithm

An algorithm is a recursive mathematical procedure, the computers stock and trade. Numerous meteorological algorithms are used in the computer programs that reside at the RPG. The products output by these programs are called Derived Products.

Purpose of Derived Products

The purpose of the meteorological algorithms is to produce products that will assist the user in rapidly analyzing the data for significant weather events. It is important to note that the Derived Products are only as good as the algorithms that produce them. Decisions should **never** be based solely on Derived Products. The Derived Products should be used like other types of computer guidance (i.e., MOS).

Algorithms complexities vary

The meteorological algorithms used by the WSR-88D vary considerably in their complexity. The numerical manipulations in some algorithms are very complex, and some are simple. Many algorithms become more complex as certain criteria are met.

Adaptable Parameters

It has long been recognized that in different climatological regimes, adjustments may need to be made to the meteorological algorithms. The values (parameters) within an algorithm that can be changed are called the Adaptable Parameters.

There are over 200 meteorological adaptable parameters in the WSR-88D. Since changing an adaptable parameter may have unexpected results on algorithm output, and affect other algorithms, most meteorological adaptable parameters are ROC controlled, meaning that you do not have the authority to change a number without ROC approval. Almost all of the meteorological adaptable parameters that can be changed at the ORPG HCI are password protected.

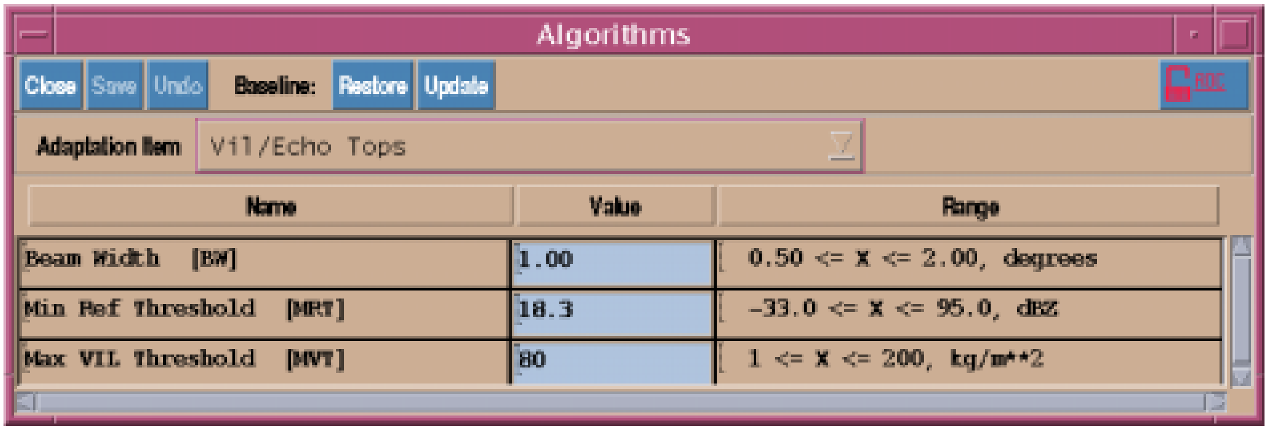


Figure 1-1. Here is an example of adaptable parameters within the VIL algorithm (RPG HCI).

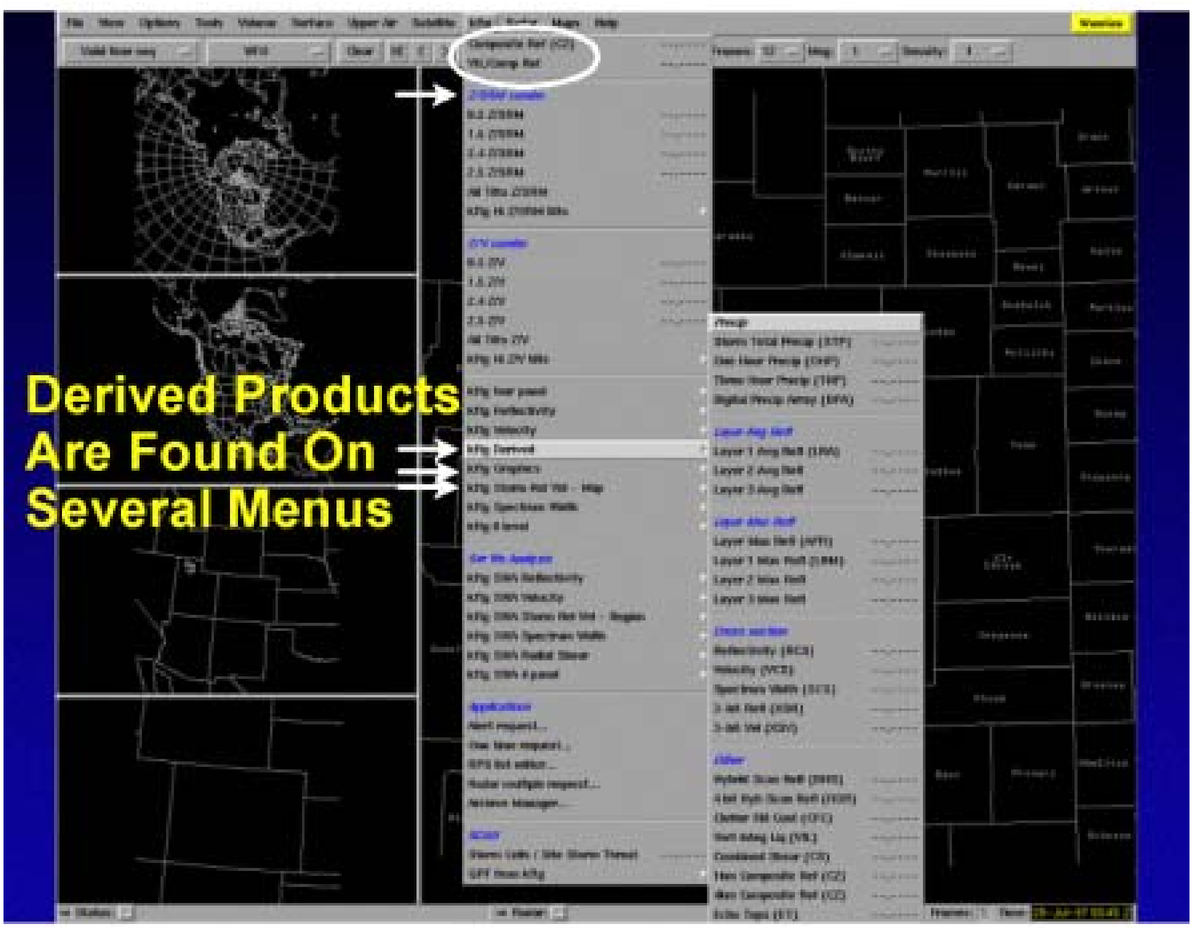


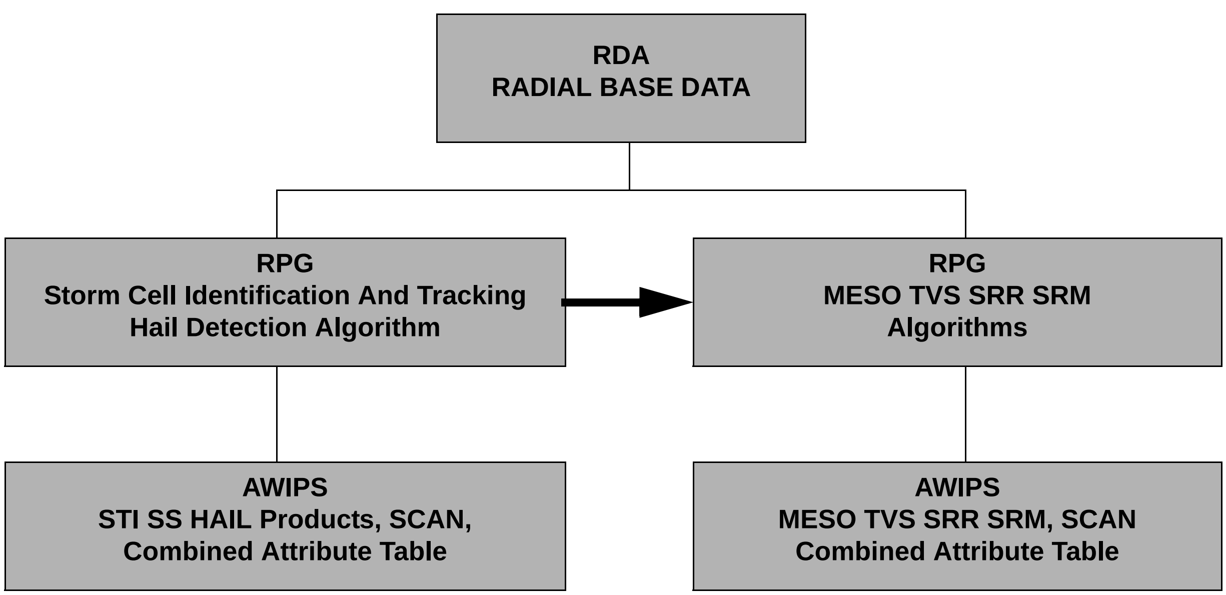
Figure 1-2. Derived products are found on several menus on the AWIPS Workstation.

Lesson 2: Storm Cell Algorithms and Products

Overview

This lesson describes how the Storm Cell Identification and Tracking (SCIT) algorithm identifies, tracks and forecast the movement of storm cells. Certain attributes of the identified cells are then utilized by the Hail Detection Algorithm (HDA) to calculate probabilities of hail and severe hail, and to estimate maximum hail size. The System for Convection Analysis and Nowcasting (SCAN) is an AWIPS application that utilizes cell attributes from SCIT and HDA combined with data from other algorithms (VIL, Mesocyclone, Tornadic Detection, and others). Descriptions, and a listing of limitations and strengths are included for the following:

1. **Storm Track Information** (STI - product #58),
2. **Hail Index** (HI - product #59), and
3. **System for Convection Analysis and Nowcasting (SCAN)**.



Objective

Without references and according to the lesson, you will be able to identify one strength and one limitation of the:

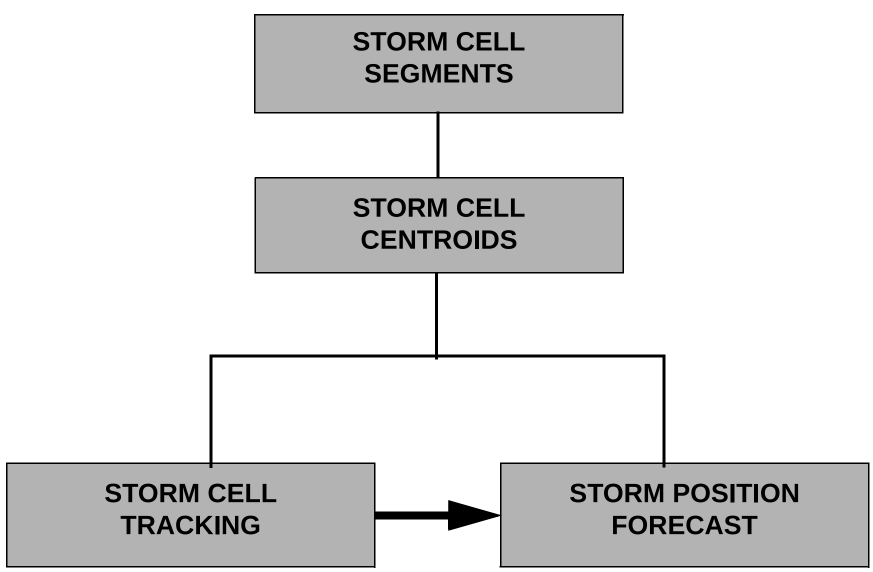
1. Storm Tracking Information (STI) product,
2. Hail Index Product (HI), and
3. System for Convection Analysis and Forecasting (SCAN).

Storm Cell Identification And Tracking

Introduction

The objective of the Storm Cell Identification and Tracking (SCIT) algorithm is to identify, track, and forecast the movement of storm cells. The primary graphic product produced by this algorithm is Storm Track Information (STI - Product ID # 58).

Data developed by this algorithm are used extensively as input to several other products (i.e., HI, SS, SRM, SRR, M, TVS, RCM, CR Combined Attribute Table) as well as SCAN.



SCIT Algorithm Overview

The SCIT algorithm consists of four subfunctions: Storm Cell Segments, Storm Cell Centroids, Storm Cell Tracking, and Storm Position Forecast. The **Storm Cell Segments** subfunction identifies the radial sequences of reflectivity (segments), and outputs information on these segments to the **Storm Cell Centroids** subfunction. The **Storm Cell Centroids** subfunction groups the segments into two-dimensional components, vertically correlates these components into three-dimensional cells, and calculates these cells' attributes. The cells and their attributes are output to Storm Cell Tracking and Storm Position Forecast. **Storm Cell Tracking** monitors the movement of the cells by matching cells found in the current volume scan to the cells from the previous volume scan. **Storm Position Forecast** predicts future centroid locations based on a history of the cell's movement.

Storm Cell Segments

Definition

Segment - a run of contiguous range bins along a radial with reflectivity values greater than or equal to a specified threshold.

Process

The Storm Cell Segments subfunction searches for segments of up to seven different **minimum reflectivity thresholds**. The segment must have a length greater than a **minimum segment length**, and may contain a specified **dropout number** of contiguous range bins that are within the **dropout reflectivity difference** below the minimum reflectivity threshold. The default values of the adaptable parameters are:

- Minimum Reflectivity Thresholds = 30, 35, 40, 45, 50, 55, 60, dBZ
- Minimum Segment Length = 1.9 km (1.1 nm or two range bins),

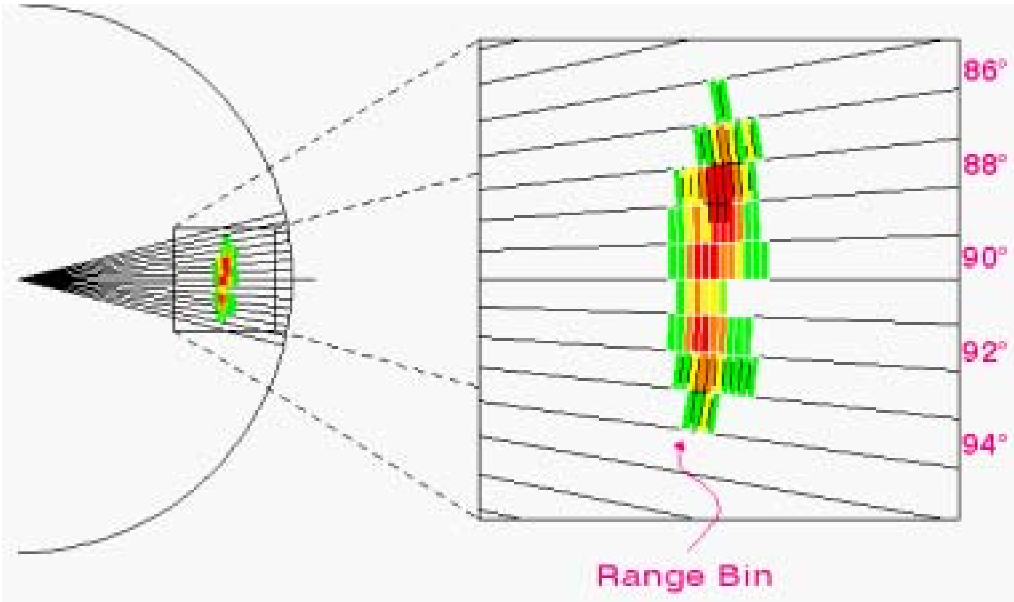


Figure 2-1. Looking closer at the radials, you can see how the reflectivity information is quantified. The basic measurements of reflectivity are made in 1° X .54nm ***range bin***. The function of this algorithm is to combine the individual range bin into storm segments along the radial. Note the segments in the figure.

- Dropout Reflectivity Difference = 5 dBZ, and
- Dropout Number = 2.

The *Storm Cell Segments* subfunction searches for segments on each radial as the data arrives at the RPG. First, a search is done for segments using the lowest minimum reflectivity (default is 30 dBZ). All other range bins are discarded from further processing. Then a search is made of the detected (30 dBZ) segments for segments of the next minimum reflectivity threshold (35 dBZ). Then a search of those (35 dBZ) segments is made for segments of the next threshold (40 dBZ), and so on through the seventh threshold (60 dBZ).

A portion of a radial is depicted in the graphic on the next page and annotated with the reflectivity values of each (1° x 0.54 nm) range bin. Given the default values of the adaptable parameters, seven segments would be defined.

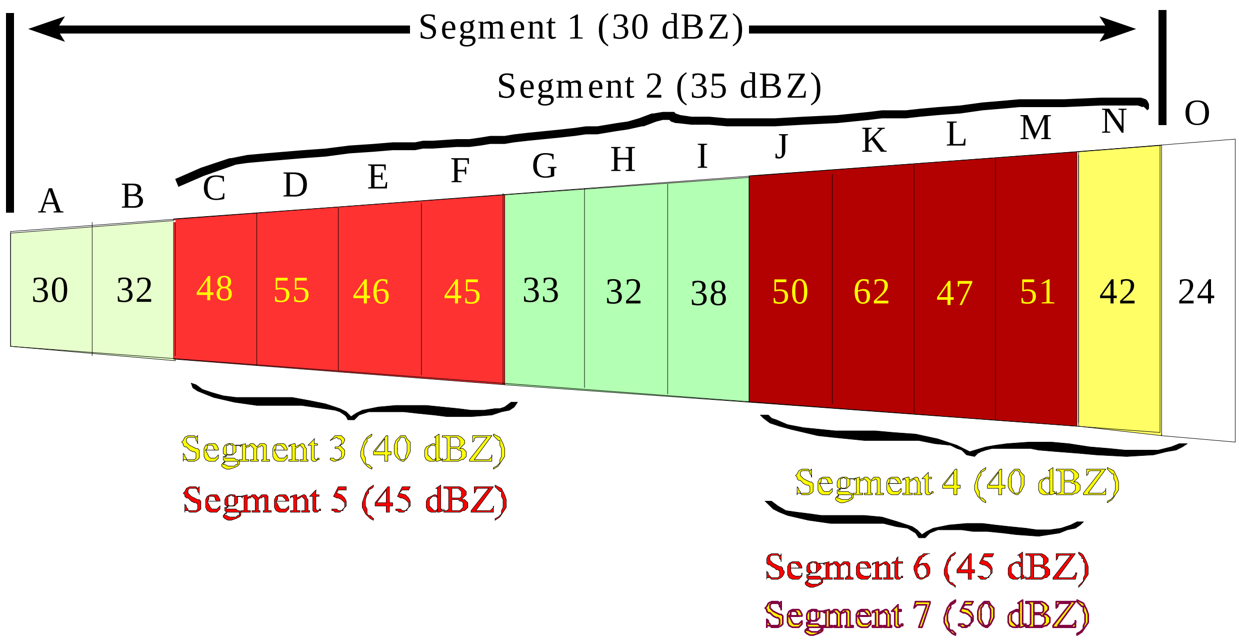


Figure 2-2. In the initial search for a 30 dBZ segment (labeled Segment 1), only the range bin labeled “O” would be eliminated. Segment 2 (“C” through “N”) would be selected in the search for 35 dBZ segments (range bins “G” and “H” would remain since up to two contiguous range bins within 5 dBZ of the minimum reflectivity threshold can be contained in the segment). The 40 dBZ segments would include Segment 3 (“C through F”) and Segment 4 (“J through N”). Segments 5 and 6 would be defined as 45 dBZ segments, and Segment 7 would be further defined as a 50 dBZ segment. Note that range bin “D” (55 dBZ) and range bin “K” (62 dBZ) would not be considered separate segments since they do not exceed the minimum segment length.

As can be seen from the example, numerous segments could be identified along a single radial. To reduce the processing task, the number of segments of a given threshold is limited to 15 (adaptable parameter) per radial. In other words, there is a potential for up to 105 segments on a single radial (7 thresholds X 15 segments per threshold). Investigations have shown that these thresholds will only be exceeded in very active weather situations.

Storm Cell Centroids

Definitions

Component - A two-dimensional area of combined segments on a single elevation slice.

Centroid - A three dimensional location of a cell’s center of mass.

Process

At each elevation slice, the Storm Cell Centroids subfunction groups adjacent segments of each reflectivity threshold into two-dimensional components. If components overlap, the component with the higher reflectivity is saved and the other(s) discarded. ***Only the smaller "bull's eyes" of high reflectivity are saved for correlation into three-dimensional cells***. Therefore, cells are defined by their areas of highest reflectivity.

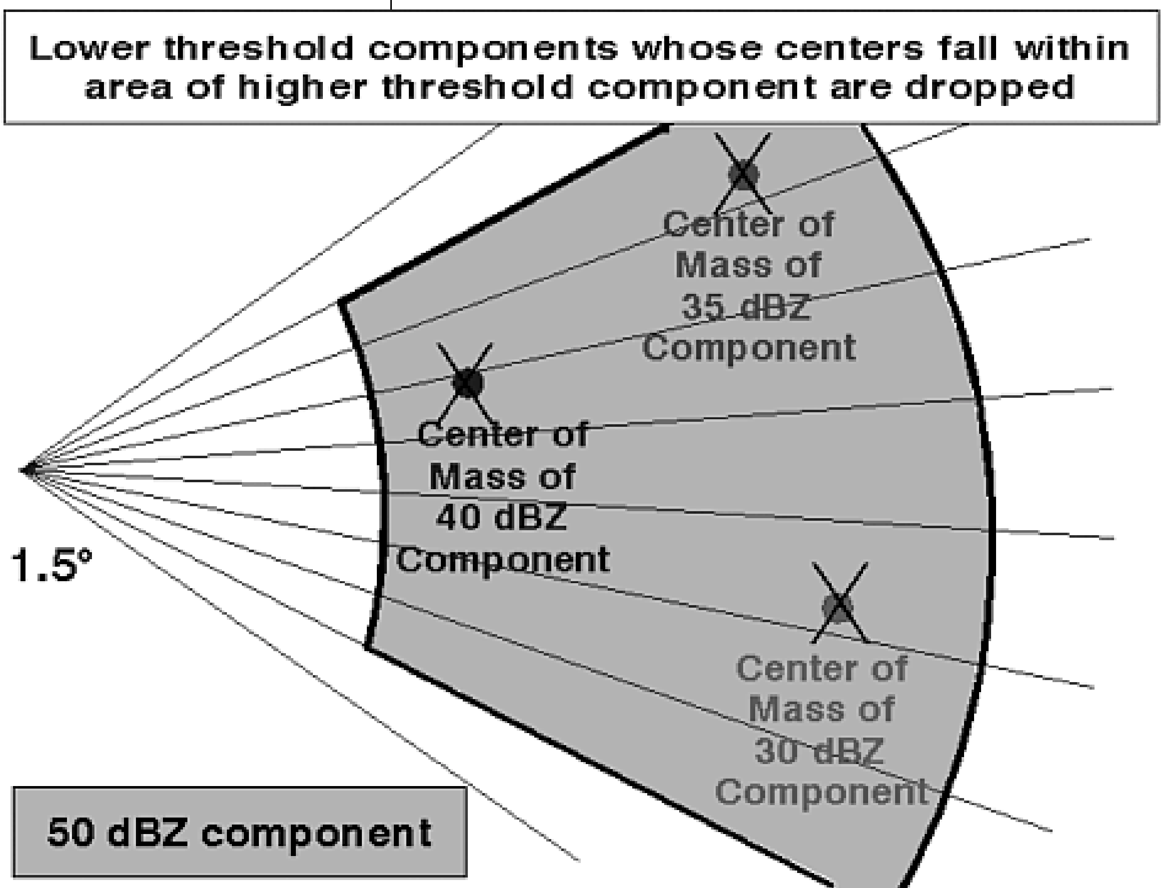


Figure 2-3. Storm Cell Centroid Processing

The components are vertically correlated by comparing the proximity of the centers of every component with those in adjacent elevation scans. Components with the largest masses are compared first. If at least two components are vertically correlated, a cell is created.

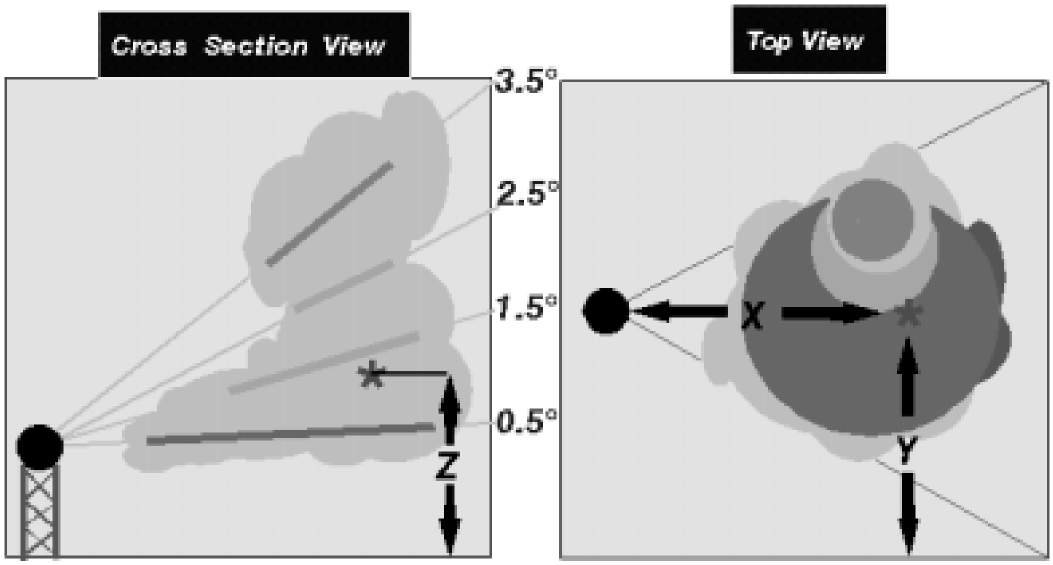


Figure 2-4. Centroid Locations

Storm Cell Centroids Output

For each identified cell the following attributes are calculated:

- centroid (in polar coordinates),
- height of the centroid (ARL - Above Radar Level),
- maximum (3-bin averaged) reflectivity,
- height of the maximum reflectivity (beam centerpoint height - ARL),
- cell base and top (ARL),
- number of components, and
- Cell-based Vertically Integrated Liquid (VIL).

Cell-based VIL

A calculation of VIL is made for each cell identified by Storm Cell Centroids by vertically integrating maximum reflectivity values of a cell's correlated components. This is a **different** calculation than the gridded VIL product (VIL - Product ID #57). As can be shown on the following example, a fast-moving or highly tilted storm will usually have a higher Cell-based VIL than Grid-based VIL.

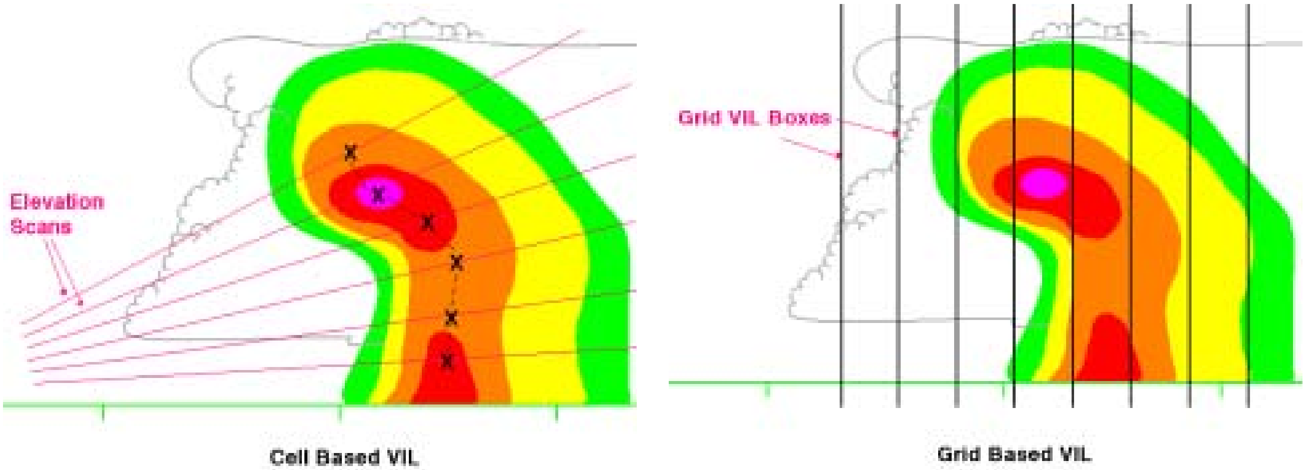


Figure 2-5. Cell-based vs. Grid-based VIL.

Up to **100 cells** can be identified by Storm Cell Centroids. The cells are ranked by Cell-based VIL. Cell-based VIL is displayed in SCAN, the Storm Structure Alphanumeric Product, and the Composite Reflectivity Combined Attribute Table.

Storm Cell Tracking

Process

Storm Cell Tracking monitors the movement of storm cells by matching cells found in the current volume scan to the cells from the previous volume scan. Starting with the cell with the highest Cell-based VIL, a comparison is done of its centroid location with the projected (based on past movement) centroids from the previous volume scan. The closest projected centroid within a threshold distance (speed limitation) is considered the same cell.

If a correlation is made, the cell is given the same ID as in the previous volume scan. If no correlation is made, the cell is given a new ID. The ID assigned to a Cell consists of a letter-number combination (A0, B0, C0 ... Z0, A1, B1... Z1, A2, B2 ... Z9). This adds some value to the ID, such as cell

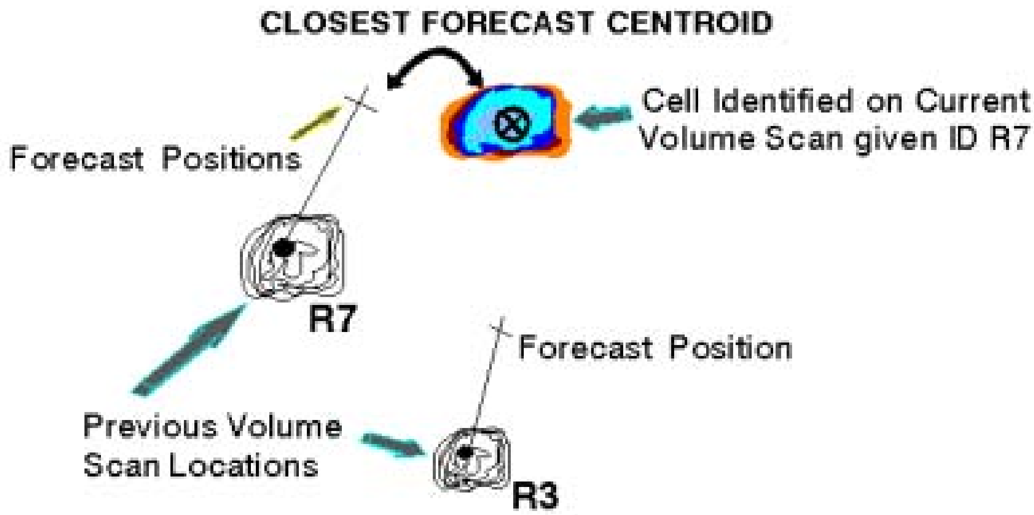


Figure 2-6. Storm Tracking Process. Centroid location is compared with forecast location of centroids from the previous volume scan.

R7 has been identified longer than cell H8 (**the number has precedence over the letter in this scheme**). The list of IDs will reset to begin with A0 when the RPG is rebooted, or when a threshold time interval has lapsed without cells.

Storm Position Forecast

Process

Storm Position Forecast predicts the future centroid locations of cells based on a history of the cell's movement. The first time a cell is detected it is labeled a new cell, and the forecast movement used by the algorithm for processing purposes is either:

a) the average movement of all identified cells, or

b) if no other cells are identified, the default speed and direction as set at the RPG HCI.

Subsequently, each time the cell is detected, a prediction is made using a linear least squares extrapolation of the cell's previous movement. A comparison of the current centroid location is made to the previous forecast position, with the duration of the forecast (0, 15, 30, 45, or 60 minutes) dependent on the magnitude of this departure. In other words, the larger the error in the past volume scan forecast, the shorter (in time) the forecast.

Storm Track Information Graphic Product

Product Description

Data developed by the SCIT algorithm is directly input to the Storm Track Information Product (STI - Product ID #58). The STI product can display up to 100 cells identified by the SCIT algorithm on a single product. It is also possible to display the actual past positions of the centroid on up to 13 (default 10) previous volume scans. Cells with a movement of less than a minimum speed (default 5 kts) are circled to indicate little movement, and past positions and forecast tracks are not displayed. The following symbols are displayed on the product:

⊗ centroid location,

• past position (volume scan increments with a line between each symbol), and

\+ forecast position (15 minute increments with a straight line connecting all forecast positions),

⊗ stationary (<5 kts).

STI Product Parameters

See Figure 2-7 for an example of the STI product.

STI product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Storm Track Info
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

STI product annotations:

- STI Attribute Table

Additional STI Product Characteristics

- RANGE: 248 nm (Effective Range 186 nm)

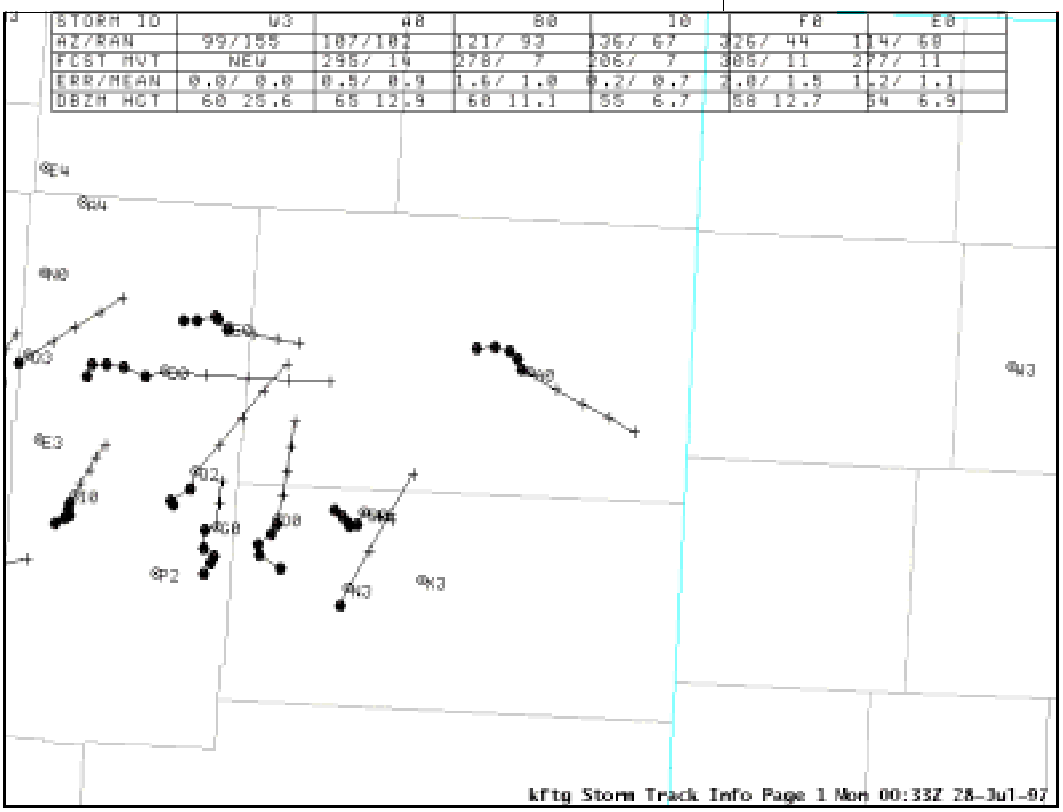


Figure 2-7. Storm Track Information (STI) Product.

STI Attribute Table

The STI Attribute Table appears at the top of the STI product, and contains information on all identified cells. The STI Attribute Table lists the cells in order of Cell-based VIL from left to right from page 1 to the last page. On the first volume scan a cell is identified, the word “NEW” is placed on the line for forecast movement.

STORM/ID	W3	A0	B0	I0	F0	E0
AZ/RAN	99/155	107/102	121/ 93	136/ 67	326/ 44	114/ 68
FCST/MVT	NEW	295/ 14	278/ 7	206/ 7	305/ 11	277/ 11
ERR/MEAN	0.0/ 0.0	0.5/ 0.9	1.6/ 1.0	0.2/ 0.7	2.0/ 1.5	1.2/ 1.1
DBZM HGT	60 25.6	65 12.9	60 11.1	55 6.7	58 12.7	54 6.9

Figure 2-8. STI Attribute Table which appears at the top of the STI product.

If 100 cells were identified, with only six cells per page, there would be 17 pages of attributes, although only 6 pages are currently viewable in AWIPS.

Storm Track Information Alphanumeric Product

An STI Alphanumeric Product is received and stored in a text file along with every STI Graphic Product. The name of the text file is in the form: ***WSRSTIxxx***, where xxx is the radar ID. The STI Alphanumeric Product is displayable at the AWIPS text workstation, and contains information on the position and forecast of identified cells. The average speed and direction of all identified cells are shown near the top of the product. Cells are listed in order of Cell-based VIL. The azimuth and range of the current cell centroids along with the movement and forecast positions at 15, 30, 45, 60 minutes are listed.

Limitations

1. ***Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.*** Recall from the previous discussion of Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.

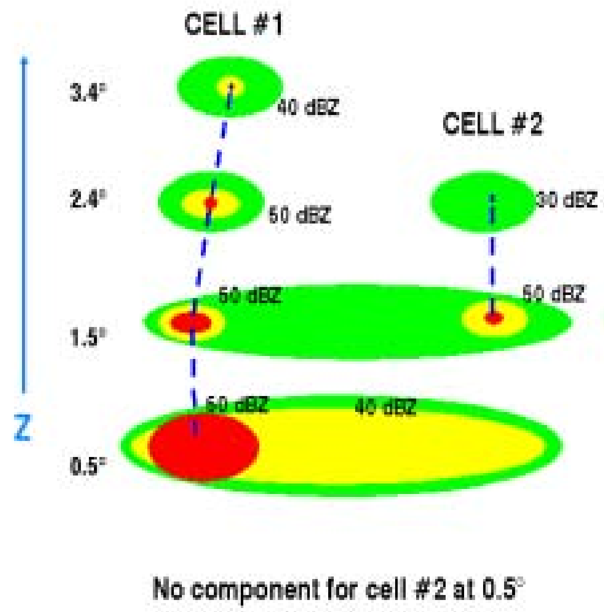


Figure 2-9. Storm Cell Centroids that storm cells are defined by areas of highest reflectivity.

In Figure 2-9, a particularly high area of reflectivity (50 dBZ) occurred in Cell #1 at 0.5°, and only this area was saved as a component. Cell #2 has been identified with a Cell Base defined at the 1.5° slice even though a 40 dBZ echo exists at the 0.5° slice.

This type of problem will also affect other calculations such as Cell Top, Maximum Reflectivity Height, and Cell-based VIL. The operator should be skeptical of cell attributes anytime cells are in close proximity to each other.

Cell attributes of supercells may also be inconsistent. The number of identified cells in a large supercell storm may vary from volume scan to volume scan. An example of this problem is seen on Figure 2-10, where cell-based VIL is compared to gridded VIL for a large supercell storm.

2. ***Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21.*** Recall that there are large gaps between elevation

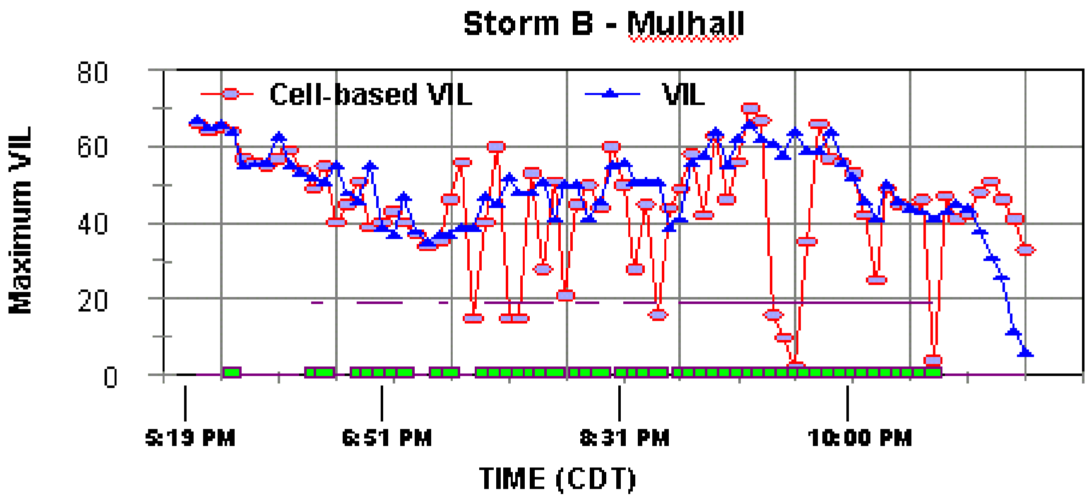


Figure 2-10. Comparison of cell-based VIL and gridded VIL for the "Mulhall" Storm that produced a long track tornado through the town of Mulhall, Oklahoma on May 3, 1999.

angles at higher slices in VCP 21. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.

3. ***Unrepresentative movements are possible due to propagational effects.*** Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.

4. ***Forecast positions of curving cells are displayed as a straight line.*** Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

These limitations should also be considered anytime the operator uses SCAN described later in this section.

Strengths/Applications

1. ***The product works best with well-defined widely separated cells***.

2. ***A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.*** Uneven spacing between past tracks, fewer than four forecast positions, and/or reidentification of cells indicate less reliable forecast positions.

3. ***The STI product is useful as an overlay on volume products, but not limited to volume products***.

4. ***Cell motion is used in Storm Relative Velocity products (SRM, SRR)*** covered in Lesson 4 (see page 75).

5. ***Cell attributes are critical inputs to the Hail Index product and SCAN.***

Radar Graphics Control

During active weather, the STI product could become extremely cluttered. Graphic controls are available at the AWIPS Workstations to allow the operator to reduce the clutter on the STI product.

The number of identified cells to be displayed (up to 100), and whether or not to display the past positions and/or forecast positions is independently selectable at each AWIPS Workstation. If 30 cells are identified by the SCIT algorithm, and an operator selects only 10 to be displayed, only the top 10 ranked by Cell-based VIL would be displayed on the STI graphic product. Information on all 30 cells are available on pages 1 through 5 of the STI Attribute Table and also on the paired STI alphanumeric product. All other AWIPS Workstations will not be effected by this setting.

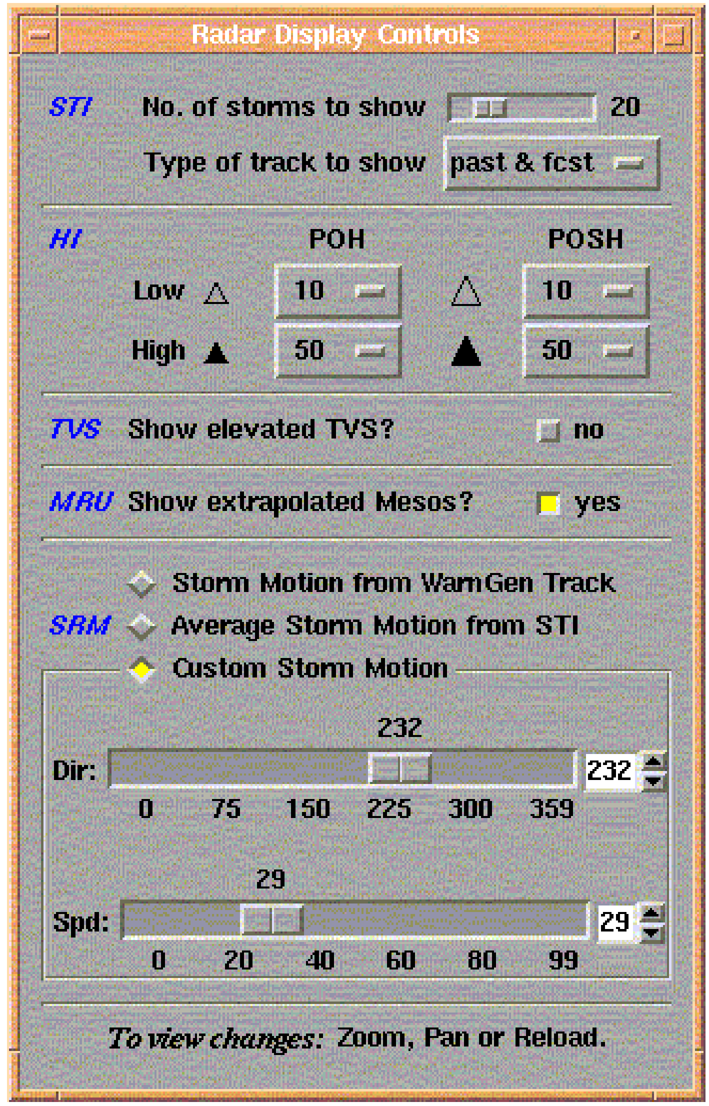


Figure 2-11. AWIPS Radar Display Controls for STI, HI, TVS, MRU, and 8-bit SRM products.

Interim Summary

1. Errors occur in cell identification and tracking when cells are in close proximity.
2. Cell identification and tracking works best when storms are separated and little development of dissipation is occurring.
3. A large number of past tracks and/or four forecast positions are indications of reliable tracking.
4. Cell attributes are unreliable in VCP 21 within 60 nm of the RDA.

Storm Track Product

Hail Detection Algorithm (HDA)

Introduction

The Hail Detection Algorithm (HDA) has been designed to look for high reflectivities above the freezing level. Input of the 0°C and -20°C altitudes at the RPG HCI from a recent representative sounding can greatly improve algorithm output. The algorithm is designed to work independent of cell type, tilt, and overhang. The primary product produced by the algorithm is Hail Index (HI - Product ID #59) which can be useful in identifying cells that have the potential to produce hail.

The Hail Index product displays the following HDA estimates:

Probability Of Hail (POH) - identified as hail of any size, displayed in increments of 10%,

Probability Of Severe Hail (POSH) - identified as hail that is $\geq$ 3/4 inch, displayed in increments of 10%, and

Maximum Expected Hail Size (MEHS) - the estimate of the largest hail size identified anywhere in the cell, computed in increments of 1/4 inch.

If the cell is beyond the hail processing range of 124 nm, then the hail estimates are labeled as UNKNOWN in the Attribute Table.

Process

The Hail Detection Algorithm searches for high values of reflectivity above the freezing level. The reflectivities used are the maximum reflectivities of cell components above the freezing level. For the calculation of the POH, the location of the highest reflectivity of at least 45 dBZ above the freezing level is found. The greater the height above the freezing level, the greater the POH. In the calculation of POSH and MEHS, reflectivities greater than 40 dBZ which exist above the freezing level are used. In addition, a weighting factor is used, such that the greater the reflectivity above 40 dBZ, and the higher the altitude at which this reflectivity exists, the greater the weighting factor used. Reflectivities greater than 50 dBZ, and higher than the altitude of the -20°C isotherm, carry the most weight. **This illustrates the need for users to update the altitude of the 0°C and -20°C levels regularly**, especially when significant change to the atmosphere is experienced near the radar coverage area.

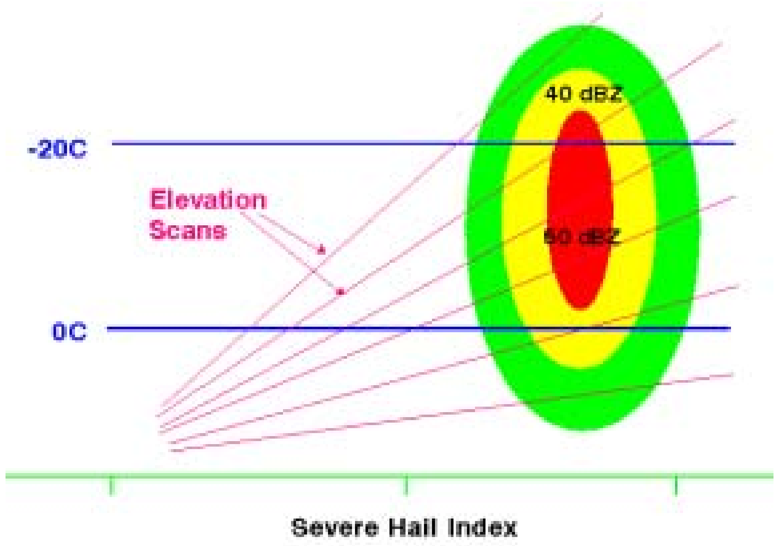


Figure 2-12. Hail Algorithm Process.

Hail Index Product

The Hail Index (HI - Product ID #59) graphic product uses symbols to depict the probability of hail. The POH will be represented with a small open or solid green triangle. For the triangle to appear the POH must exceed a **"Minimum Display Threshold"**(10% default). Whether the triangle is open or solid green depends on a **“Fill-in Threshold”** (50% default). The POSH is represented by a larger green triangle, again with the solid green triangle representing a “fill-in” threshold. The MEHS will be displayed in the center of the POSH symbol rounded to the nearest inch from 1 to 4. If a cell has hail identified that is less than 3/4 inch, then an asterisk (*) will be placed in the center of the POSH symbol.

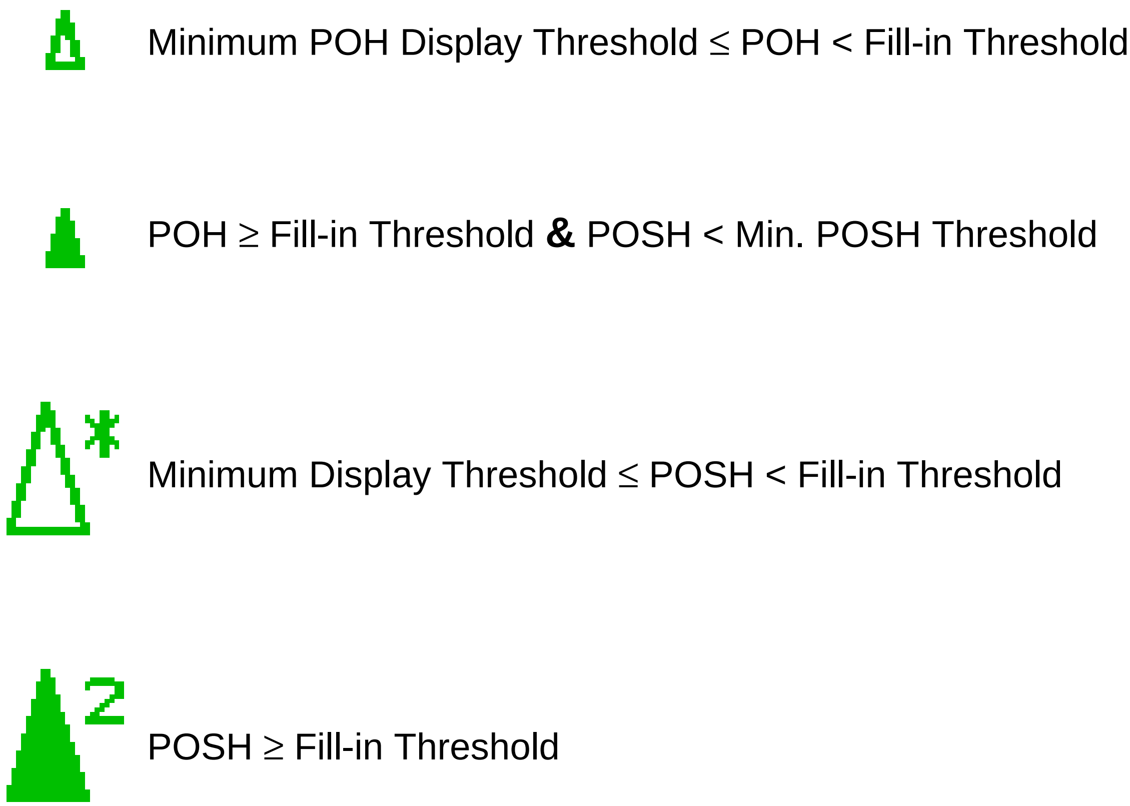


Figure 2-13. Hail Symbols

Hail Index Attribute Table

The Hail Index Attribute Table will be available at the top of the product which lists the Cell ID, Azimuth and Range, POSH or POH, the MEHS (to the nearest 1/4 inch), and the last line in the table identifies the altitudes of the temperatures and the date/time at which the information was last updated, (1/1/96 12Z is displayed if data has not been entered). Each page of the table can contain up to 6 cells. Cells are ordered first by POSH and then by POH. In addition, the parameters of POSH, POH, and MEHS will be displayed in the Composite Reflectivity Combined Attribute Table and the Hail Index alphanumeric product.

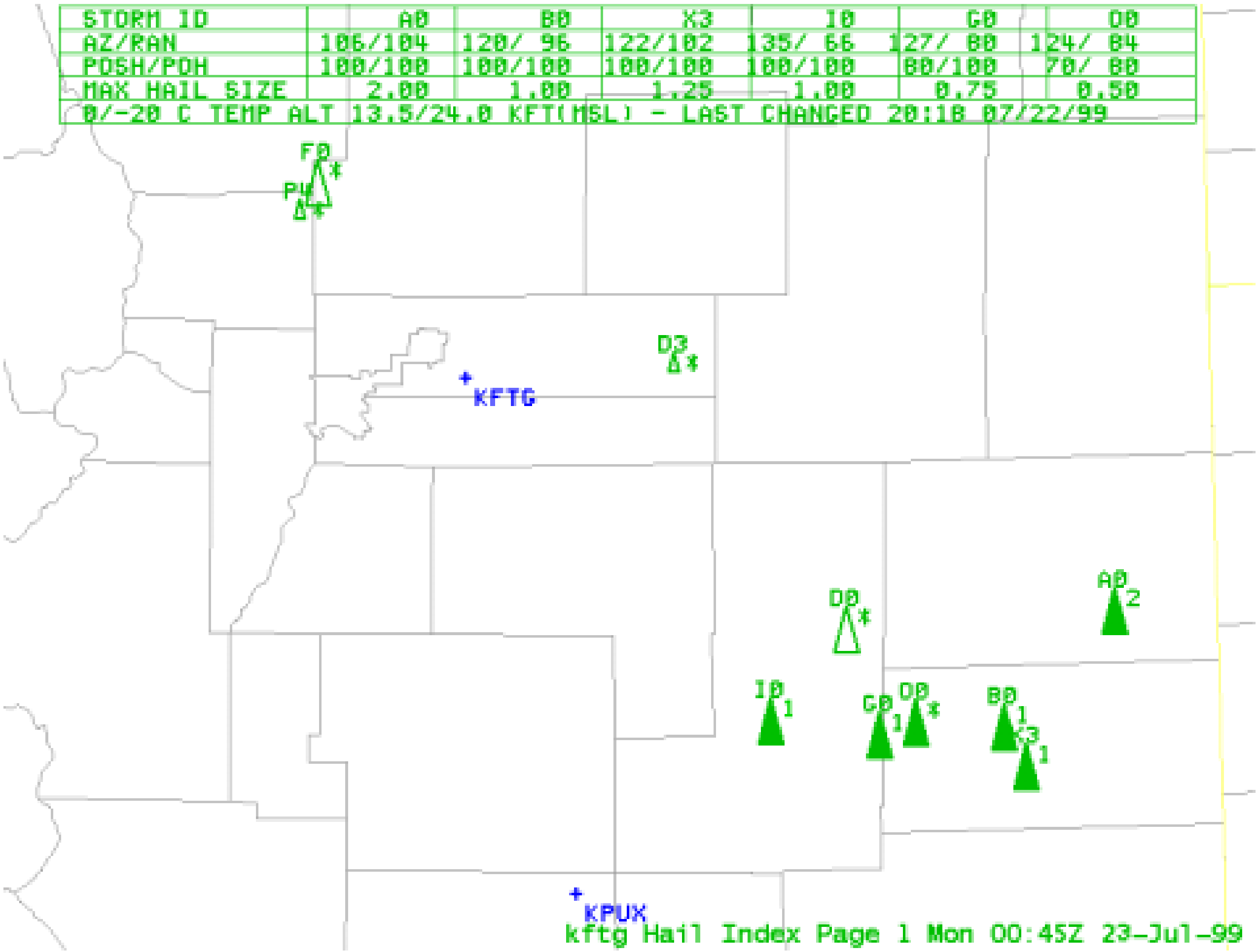


Figure 2-14. Hail Product

Graphic controls are available at the AWIPS Workstations to allow the operator to adjust the Minimum and Fill-In Thresholds for the Hail Index Icons. These changes will not be viewable until the

Icon Graphic Controls

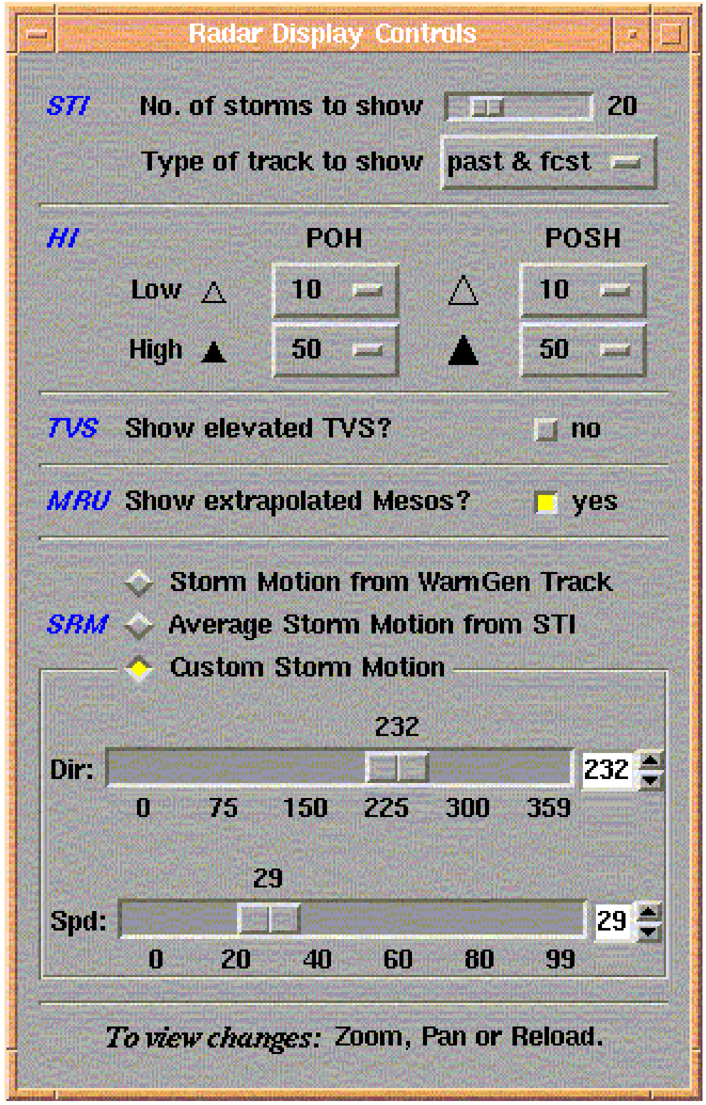


Figure 2-15. AWIPS Radar Display Controls for STI, HI, TVS, MRU, and 8-bit SRM products.

product is zoomed or reloaded. Changes made here will not effect other AWIPS workstations.

Hail Temperature Height Selection

The 0°C and -20°C heights used by the Hail Algorithm can be entered at the RPG HCI under the Environmental Data, to allow (under URC authority) the operator to input the most recent altitudes (see Fig. 2-16).

These values should be obtained from representative sounding information. If no recent nearby

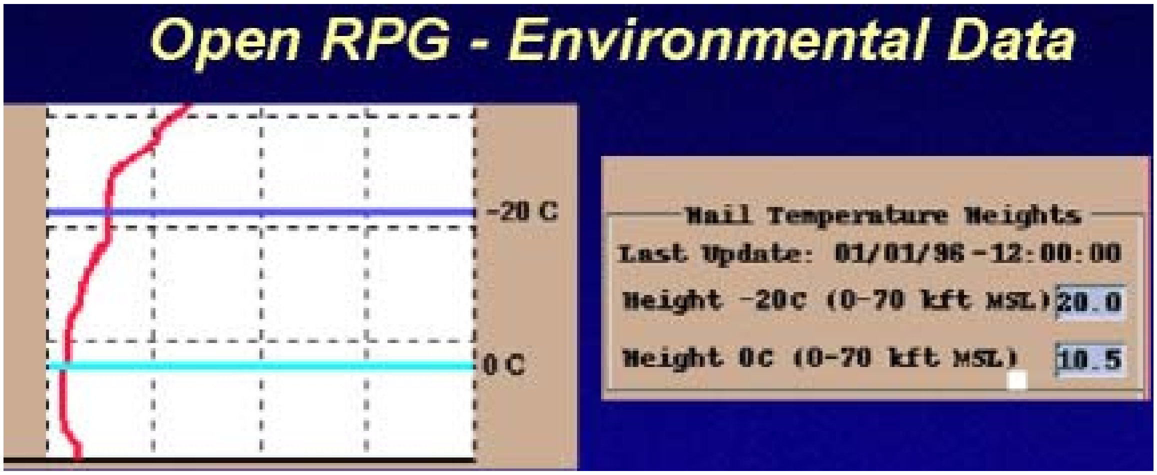


Figure 2-16. Hail Temperatures edit screens at the RPG HCI.

sounding is available, a forecast sounding or interpolation from surrounding soundings is recommended. **This should be done twice daily or as meteorological conditions warrant for the algorithm to provide accurate hail estimates.**

Limitations

1. The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0°C and -20°C levels. Failure to update this information will degrade the algorithm's performance.

2. Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCP 21, due to gaps in coverage at higher elevation slices.

3. The values for POH, POSH, and MEHS may fluctuate at longer ranges from the radar due to the limited number of slices through the cell.

4. The maximum hail processing range is 124 nm. **For cells beyond 124 nm, hail will be identified as UNKNOWN**.

5. POSH and MEHS tend to overestimate the chances and size of hail in weak wind and tropical environments. The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information.

MEHS is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller.

The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

Strength / Application

The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail. **A POSH of 50% or greater has shown skill as a warning threshold.**

System for Convection Analysis and Nowcasting (SCAN)

Introduction

SCAN is a tool to aid forecasters in the process of monitoring for the potential of severe convection. One of the goals of SCAN is to mitigate the information overload that can sometimes overwhelm the forecaster. For example, SCAN can provide guidance to compel the forecaster to investigate certain storms more closely.

SCAN provides extensive information on radar-derived storm cell parameters, such as location and movement, TVS, Meso, output from the Hail

Detection Algorithm (POSH, POH, and Hail Size), VIL, and many others.

This following is a brief overview of SCAN. For a more complete review it is suggested that students review the SCAN OB1 Users Guide (or later version) available on the SCAN Home Page at **http://www.nws.noaa.gov/mdl/scan/index.htm.** A recorded VISITview session is also available at **http://www.wdtb.noaa.gov/DLCourses/SCAN/replay/index.html**

How SCAN Works

SCAN utilizes six radar products (CZ, TVS, M, STI, VIL, and 0.5° Z), lightning files, LAPS files, and MDL-developed algorithms to display cell attributes both in tabular and graphic forms. Many of the cell attributes used by SCAN are taken from the Composite Reflectivity (CZ) Combined Attribute Table to be discussed later. The CZ Combined Attribute Table contains cell attribute information from both the SCIT and HDA algorithms.

How to Display SCAN

To view a radar's SCAN output in a cell table window on a particular WS, the user selects the corresponding Storm Cells/Site Storm Threat from the SCAN menu in the D2D session (see figure 2-17 on page 28). This request generates a cell table window outside of the D2D session. The TVS file data are used to display the SCAN TVS table launched from the cell table. The Meso file data are used to display the SCAN Meso table also launched from the cell table.

SCAN Storm Cell Table

The SCAN Storm Cell Table contains a myriad of information for each identified storm (see Fig. 2-18). The SCAN Storm Cell Table can be

Figure 2-17. SCAN submenu.

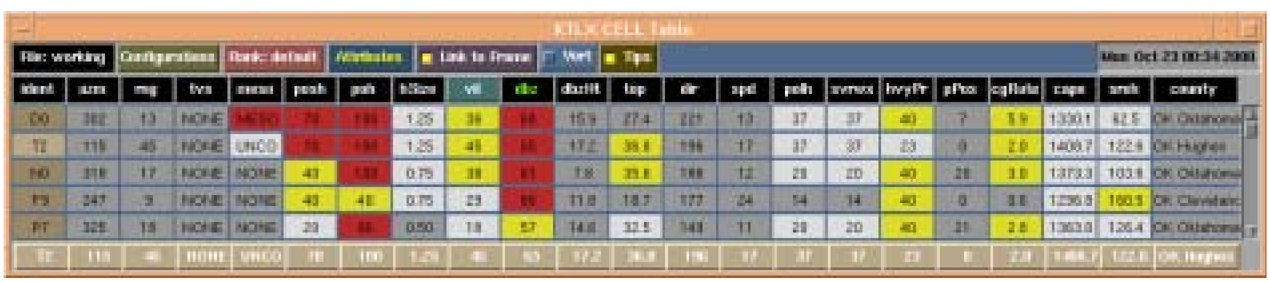


Figure 2-18. SCAN Storm Cell Table.

configured to meet user needs and preferences. Each configuration can be saved and retrieved using the **File menu**.

The **Configurations menu** includes choices to set up the D2D display, change alarm parameters, control the trend function, and control the color thresholds of storm cell attributes (box colors).

The **Rank menu** allows the user to choose the storm cell attribute by which the data in the table body will be sorted. For example, clicking on VIL in the Rank menu will cause all the cells to be ranked by their cell-based VIL values.

The **Attributes menu** allows the user the option to choose which of the available storm cell attributes will appear on the storm cell table.

The **Link to Frame** button is a toggle button that links the time in the cell table to the time of the scan storm cell display product in the D2D session.

The **Vert** button is a toggle button that allows for either a vertical or horizontal orientation of the storm cell table.

The **Tips** button is a toggle button to turn off or on the tips functionality. When on, and the mouse cursor is located over a "clickable" widget, a pop-up text window appears with useful information about that widget.

On the far right is the **Valid Time Box** indicating the UTC time for which the data in the storm cell table are valid.

The SCAN Graphic

A D2D graphic is linked to the SCAN Cell Table and will change zoom (as noted above) upon left clicking on the storm cell ID in the SCAN cell table. The SCAN Graphic appearance is configurable to display certain attributes as circles and arrow.

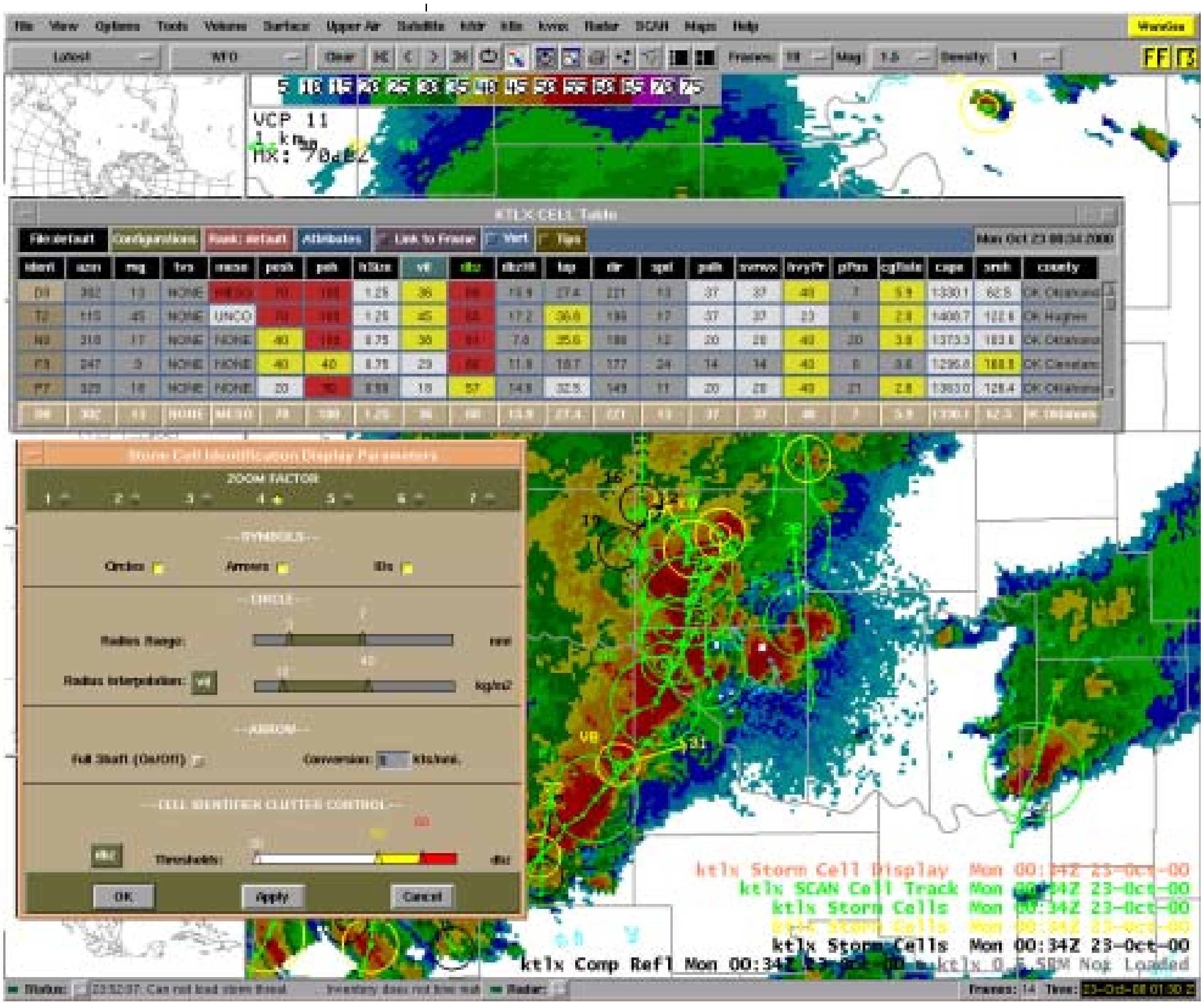


Figure 2-19. Storm Cell Identification Display (SCID) window.

The SCID Window

The Storm Cell Identification Display (SCID) window, launched from the Configurations menu, allows the user to control the zoom factor of the inspected cell and the appearance of the storm cells displayed on the D2D window. (See Fig. 2-19 on page 30.) Appearance of the symbols in D2D can be broken into **circles, motion vectors (arrows), and storm ID labels**. An operator can select whether or not to display everything except for the past/future tracks by toggling the buttons located under the “Symbols” label inside the SCID window. When arrows are displayed, the arrow length can be configured by a cell speed conversion factor. The **radii of the circles** around each plotted storm cell centroid on the D2D are set to be proportional to the value of a chosen attribute. Additionally, the **circles are assigned colors** (white, yellow, red) based upon threshold values of a particular cell attribute chosen in the Cell Identifier Clutter Control.

SCAN Alarms

On the occasion when a Rate-of-Change Alarm threshold has been surpassed, a **blinking alarm** button will appear to the left of the Valid Time Box. Right clicking on the alarm button will toggle the audible alarm while left clicking will bring up the Alarm Information Window.

Rate of Change Alarm Threshold Window

SCAN has an alarm function that can be used to alert an operator to significant increases in particular storm cell attributes between the last two complete volume scans. If a particular storm attribute exceeds the specified rate-of-change, an alarm button appears next to the time box in the cell table. An audible alarm sounds at the same time. Left clicking on the alarm button allows the user to view the alarm triggers and clear the alarms. By **left clicking** on an individual alarm cell, a trend for the alarmed cell and attribute will appear, the D2D display will zoom to the alarmed cell, and the inspection row in the SCID window will fill up with information on the alarmed cell. A user may clear all the alarms by left clicking on the **"Clear All Alarms"** button. See Fig. 3-1 on page -36 for an example of an alarm information window.

An operator has the ability to modify the alarm settings. The **New Alarm Time Setup Window,** launched from the Configurations menu, allows the user to set time thresholds for determining when new SCAN alarms are issued. These new alarms are issued with new cell activity or when a

Meso or a TVS is identified after a quiet period that is set by the user. The window name is labeled as Alarm Time Limits for KXXX (where KXXX is the radar ID). The **Rate-of-Change Alarm Threshold Window**, also launched from the Configurations menu, allows the user to set thresholds for the rate of increase of a particular attribute on which SCAN issues an alarm. The Rate-of-Change Alarm Threshold Window is labeled as the "Cell Alarm Thresh" window as shown in Figure 1.

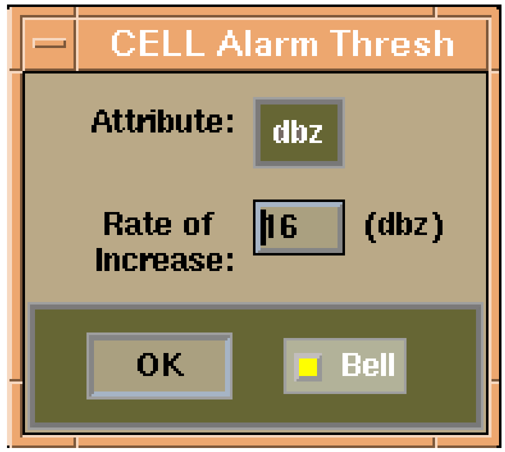


Figure 1. Cell Alarm Threshold Windows.

The SCAN CWA Threat Index (SCTI)

SCAN includes a GUI button display that affords the user a quick assessment of the general threat of severe weather over the County Warning Area (CWA). Two buttons are located below the WarnGen button on the D2D; the right one with the severe thunderstorm symbol indicates the maximum value of the SCTI in the CWA. Placing the cursor over one of the two buttons will produce a small text tip widget with information on the maximum value of SCTI over the CWA.

The SCTI is created by searching for several thunderstorm parameters that fall closely to a radar-centric field of 4 X 4 km grid boxes. These include VIL, 4 km CZ, cloud-to-ground lightning (CG), presence of Meso and TVS detections and a Severe Weather Probability (SWP) based on VIL and environmental proximity sounding information. For more information on the SWP, see:

`http://www.wdtb.noaa.gov/dlcourses/scan/swp/awipssvr.html`

These ingredients are combined into the SCTI whose values range from 10 to 100. For display purposes, the SCTI is color coded. Table 3, shows the relationship between the SCTI values, the input ingredients and the color coding. If the SCTI button is **grey** then SCAN is not running.

The SCTI product can also be displayed as a 4 km **radar-centric gridded product** selectable from the SCAN section of the D2D menu. The gridded SCTI has the same color scheme as that of the buttons described above.

Table 3: SCTI Values

SCTI = 100	Cell SWP ≥ 70, MESO and TVS	**red**
SCTI = 90	Cell SWP ≥ 70, MESO or TVS	**red**
SCTI = 80	Cell SWP ≥ 70	**red**
SCTI = 70	30 ≤ Cell SWP < 70, MESO and TVS	**yellow**
SCTI = 60	30 ≤ Cell SWP < 70, MESO or TVS	**yellow**
SCTI = 50	30 ≤ Cell SWP < 70	**yellow**
SCTI = 40	Cell SWP < 30, MESO and TVS	**yellow**
SCTI = 30	Cell SWP < 30, MESO or TVS	**yellow**
SCTI = 10	CG LTG, high VIL, high reflectivity	**green**
No activity		**white**

Storm Site Threat

The **Storm Site Threat** product informs the user of the level of threat imposed on a geographical site by proximity to storms. Displayed in D2D, geographical sites (e.g., towns) are identified as tiny squares under benign conditions.

Under threatening conditions, the squares enlarge and show the site name. The Storm Site Threat display is invoked along with the SCAN Cell Table and the storm cell graphical display in D2D. See Figure 3-1 on page 36 for an example of the site threat display in D2D.

Pressing the left mouse button (keep it pressed) and moving the cursor over the local sites allows popup information regarding the status of these sites to be displayed by the cursor. These include:

- Site name
- Threat at site; yes or no;
- If there is a threat, a reason for its existence
- Status of the SCAN processor (whether radar data, lightning data or both are available)

This product is designed to show threats commeasurate with aviation concerns. Therefore, both severe and nonsevere thunderstorms within 10 nautical miles of the site (typically airports) will increase the site threat values.

Time Trends

A time trend for a particular cell can be invoked for the cell attribute in question by **left clicking** on the table grid box containing the particular attribute for that cell. As an example, for cell ID T2, left clicking on the VIL for T2 will invoke a time trend of VIL.

A trend set window can also be invoked by **right clicking** on the storm cell ID identifier box. The parameters to be shown in the trend set window can be determined by going into the Trend Set option within the Configurations menu in the Menu/Information bar.

Two trend windows (dBZHT and top) also display the trend of the altitude of each radar beam as it passes through the cell. The trends of the radar beam altitudes can then be compared to the height trends of the dBZHT and top parameters in order to help assess the accuracy of these parameters. For example, Fig. 2 on page 37 shows a trend of a storm top marked by a dark line with circles and the trends of all radar beams at the storm location marked by thick white lines. The user can then assess the vertical sampling resolution available to create the storm top trend (roughly 5000 ft in Figure 2).

In addition to a single trend window, a group of two to five trends called a trend set can be displayed by two methods:

1. Right clicking on a storm-cell ID box in the Cell Table.

2. Right clicking on the cell centroid in the D2D window when the Storm Cell Display is made active or editable. Right clicking on the “Storm Cell Display” text label in the bottom right portion of the main D2D pane and selecting editable activates this functionality.

The parameters to be shown in the trend window can be chosen using the Trend Set selection within the Configurations menu in the cell table. A particular group of parameters for a trend set can also be saved with a trend set name, edited or deleted. Once the trend set window is displayed, the operator can use the Storm ID and Trend Set Name buttons on the top of the window to view trend sets for any identified cell.

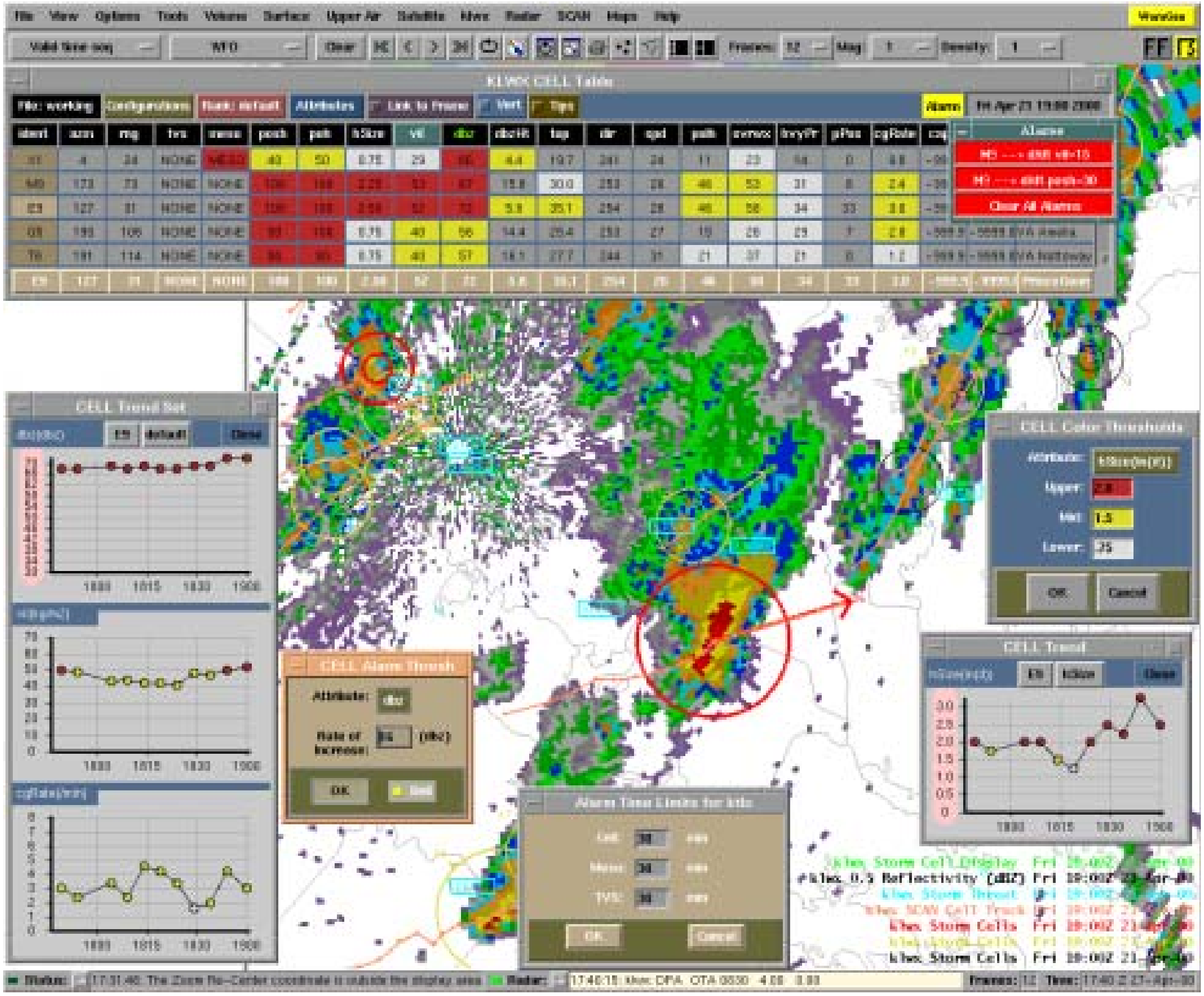


Figure 3-1. Rate of Change Alarm Threshold Window.

Limitations

1. **Limitations of algorithms used as input to SCAN must be considered.** For example, height attributes of cells such base, top, height of maximum reflectivity, etc. can be adversely affected by gaps between elevation slices (especially in VCP 21). In some cases a trend decreasing cell depth may be displayed, when in fact the cell is increasing in depth.

2. **SCAN output is not available as early as derived products**. SCAN may take over a minute longer to process and display data from

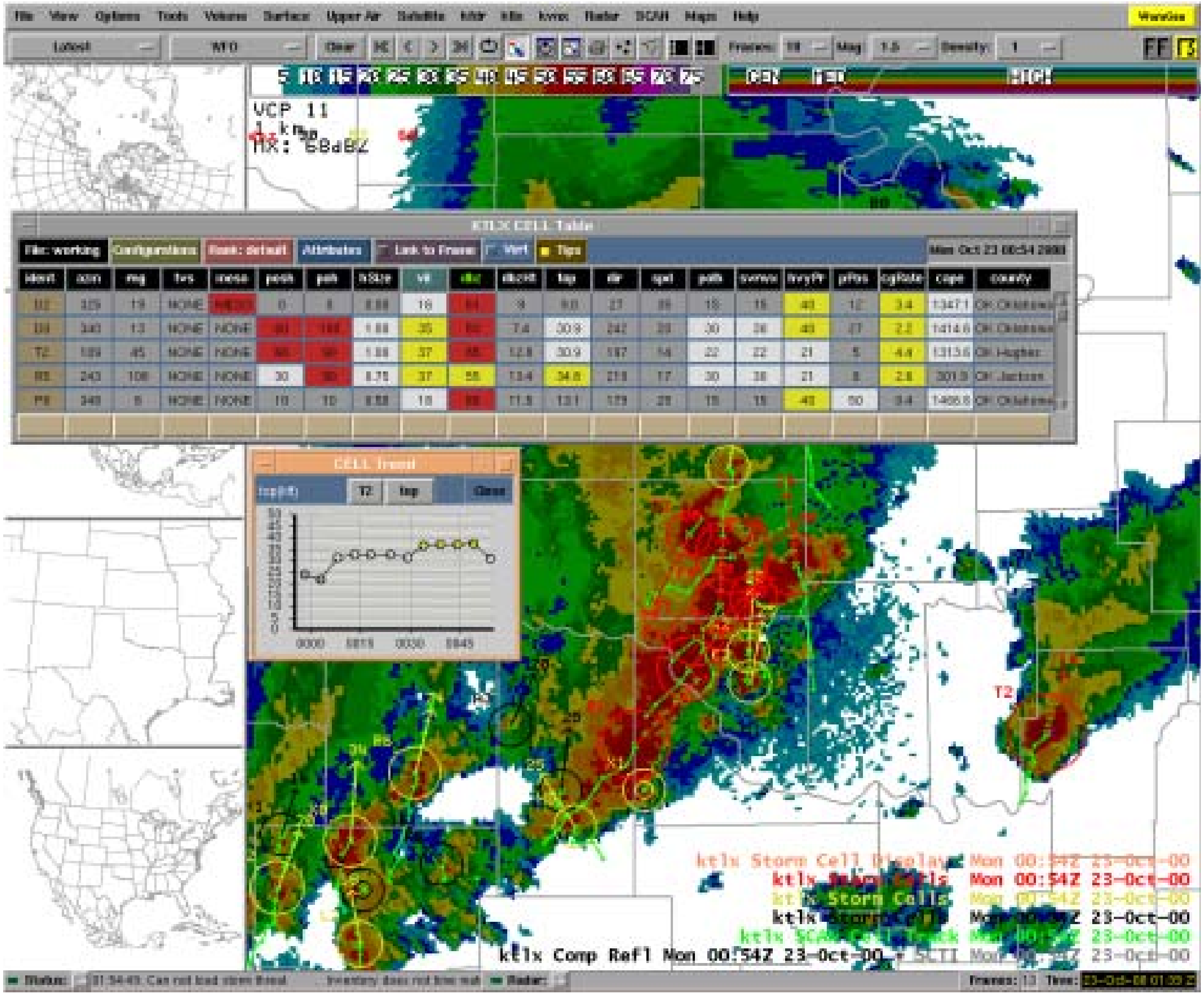


Figure 2. Single-Trend Window. Well sampled storm top trend with an overlay of the radar beam heights.

the radar products used as input (such as, Storm Track Information, Combined Reflectivity, VIL, Mesocyclone, and Tornadic Vortex signature).

3. **For optimal use, considerable local configuration of SCAN Tables, Graphics, and Alarms is required.**

Strength / Application

1. **A large amount of information on an individual cell is displayed on a single easy-to-interpret display.**

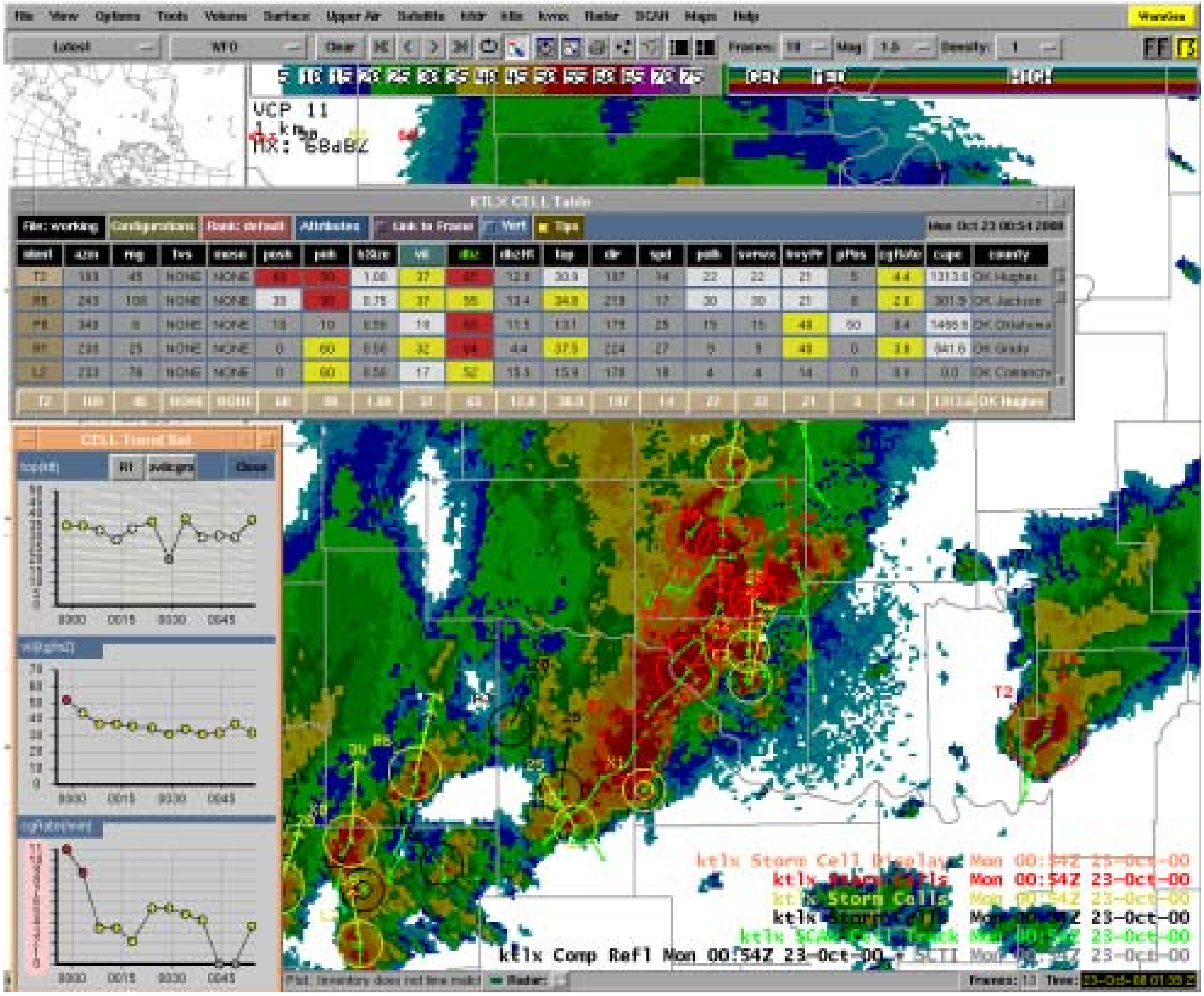


Figure 3. Multi-Trend Window. Example of a trend set with an incorrect storm top at 0030 UTC.

2. **For well tracked cells that are greater than 20 nm from the RDA, trends of cell attributes can provide a reasonably accurate view of cell evolution.**
3. **If properly configured, rate of change alarms can alert operator to the need for further investigation or provide “safety net.**

Interim Summary

Hail Index Product

1. Hail Index (HI) displays three values: Probability of Severe Hail (POSH), Probability of Hail (POH), and Maximum Expected Hail Size (MEHS) for identified cells.
2. Hail attributes are calculated by comparing SCIT defined component maximum reflectivity heights to operator input heights of the 0 and minus 20 degree heights.

System for Convection Analysis and Nowcasting (SCAN)

1. SCAN produces a table and graphic of cell attributes from the SCIT and HDA algorithms along with other algorithms such as Mesocyclone (Meso) and Tornadic Vortex Signature (TVS).
2. SCAN produces time trends of cell attributes. For well sampled storms these trends can indicate cell evolution.
3. Local configuration of SCAN tables, graphics, and alarms are needed for optimal use.

Lesson 3: Reflectivity Based Products

Reflectivity Related Products

1. Vertically Integrated Liquid
2. Reflectivity Cross Section
3. Composite Reflectivity
4. Layer Composite Reflectivity Maximum
5. User Selectable Layer Reflectivity
6. LRM Anomalous Propagation Removed (APR)
7. Echo Tops

Objectives

Without references and according to the lesson, you will be able to ***identify one strength and one limitation of the following products:***

1. Vertically Integrated Liquid
2. Reflectivity Cross Section
3. Composite Reflectivity
4. Layer Composite Reflectivity Maximum
5. User Selectable Layer Reflectivity
6. Echo Tops

Vertically Integrated Liquid (VIL)

Process

VIL values represent reflectivity data converted into equivalent liquid water values. What you are really viewing is integrated reflectivity, <u>not</u> a storm's precipitable water content, as was the original intent.

The VIL equation is:

$$M = 3.44 \times 10^{-3} Z^{4/7}$$

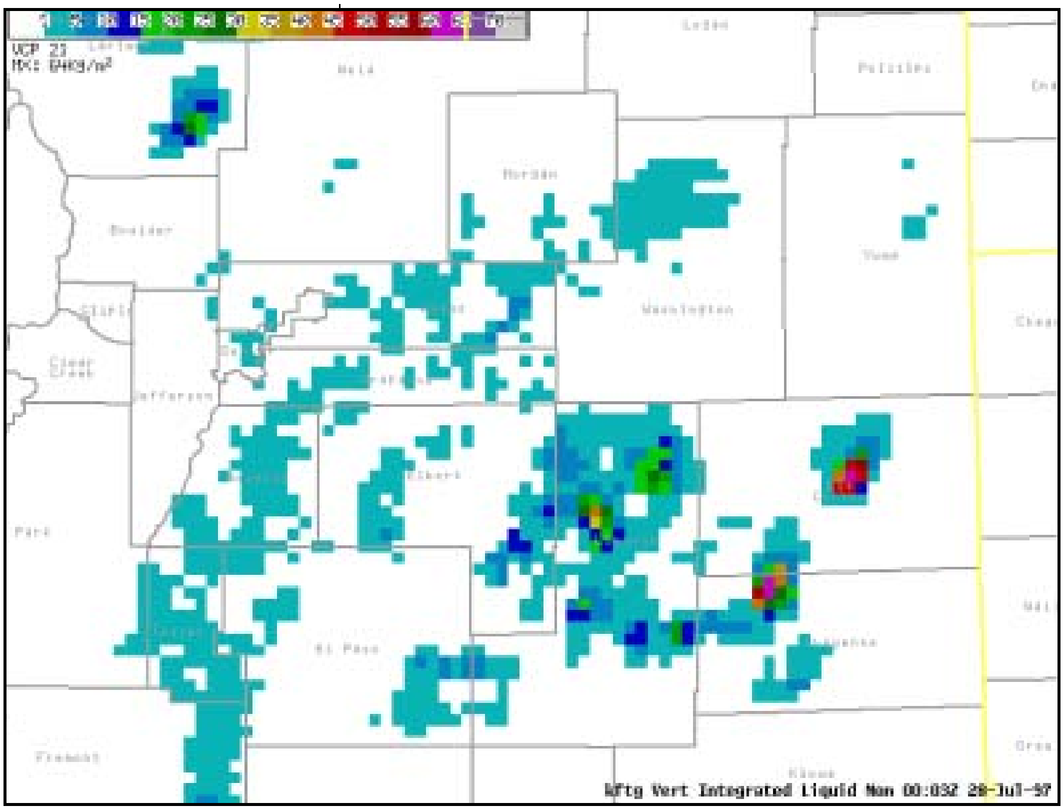


Figure 3-1. Vertically Integrated Liquid (VIL) product

where M = liquid water content (g m-3)

Z = radar reflectivity (mm6 m-3)

The values are derived for each 2.2 x 2.2 nm grid box; then vertically integrated. VIL values are output in units of mass per area (kg m^{-2}).

The algorithm ***assumes reflectivity returns are from liquid water.***

Reflectivity returns from hail are non-linear & would result in unrealistically high values, so all reflectivities greater than 55 dBZ are truncated to 55 dBZ.

VIL Product Parameters

See Figure 3-1 for an example of the VIL product.

VIL product legend description:

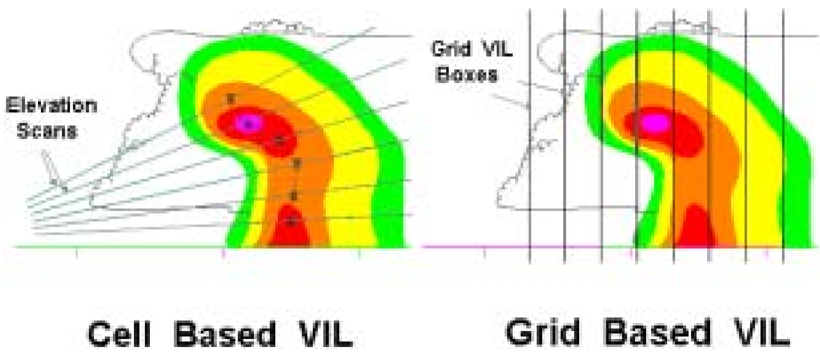


Figure 3-4. Cell-based vs. Grid-based VIL.

- RPG ID: kxxx
- PRODUCT NAME: Vert Integrated Liquid
- DATE: Day of week, time, and date in UTC

VIL product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum value in kg/m^2. The location of this value is unknown.

Additional VIL product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values range from 1 kg/m^2 to 70 kg/m^2.

VIL Limitations

1. **VIL values are biased by drop size.**
2. **Values for warnings may change daily and across the *warning area.*** Values are airmass dependent.
3. **Values within 20 nm of radar are <u>underestimated</u>.** This is due to the cone of silence.
4. Grid VIL values will differ from Cell-Based VIL values.
5. VIL values for a strongly tilted or a fast moving storm will be ***lower*** than if the storm was verti-

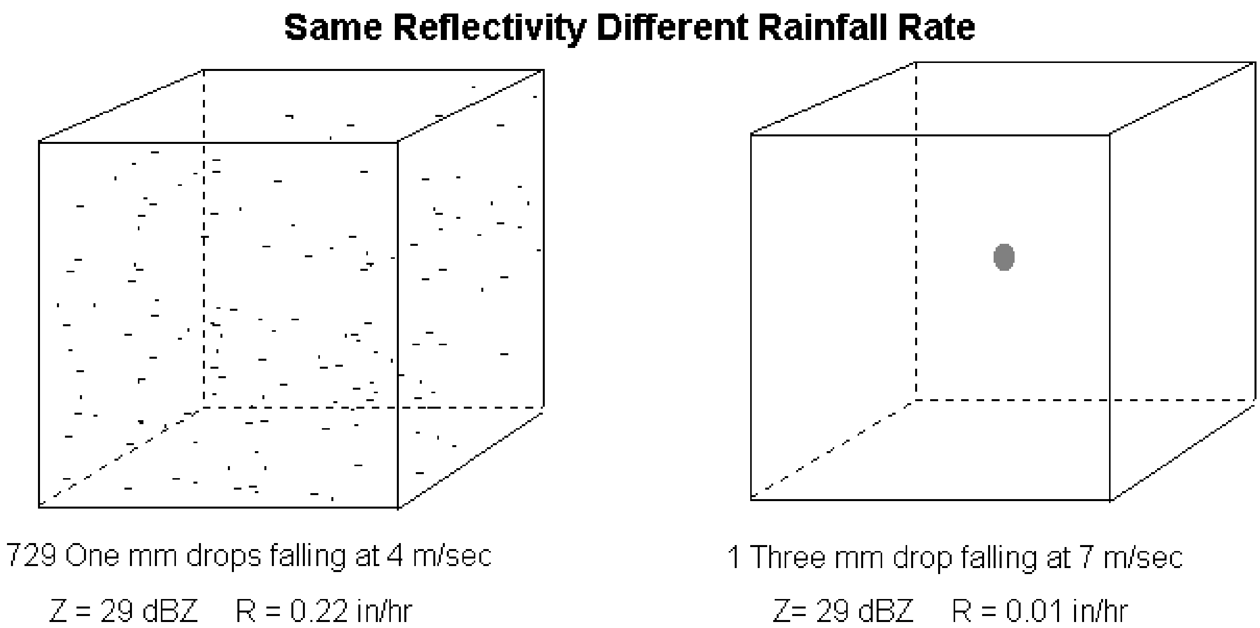


Figure 3-2. Effect of drop size on target reflectivity

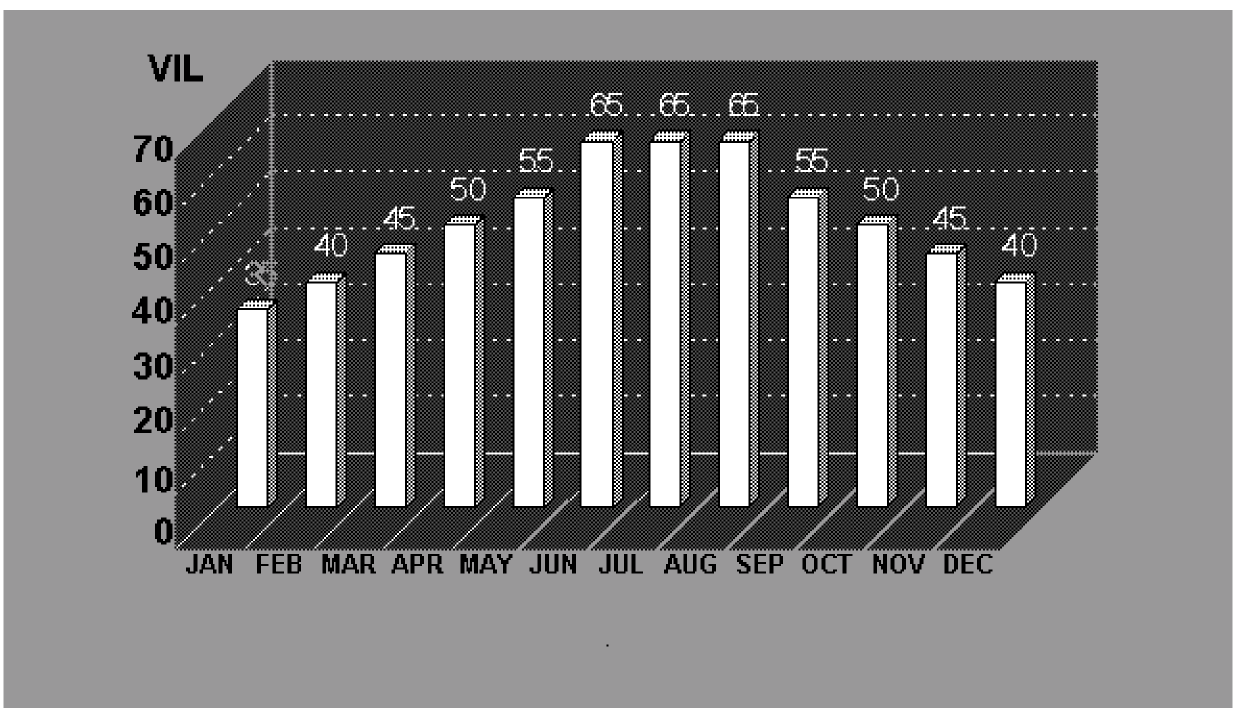


Figure 3-3. Estimated VIL values needed for large hail in Oklahoma.

cal or moving slower. The upper portion of the storm may extend into another grid box.

6. May be contaminated by non-precipitation echoes.

7. ***More VIL fluctuation with VCP 21 than VCP 11.*** There are fewer gaps in VCP 11. This is mainly within 60 nm of the radar. This study is of observed VIL values.(see Fig. 3-5))

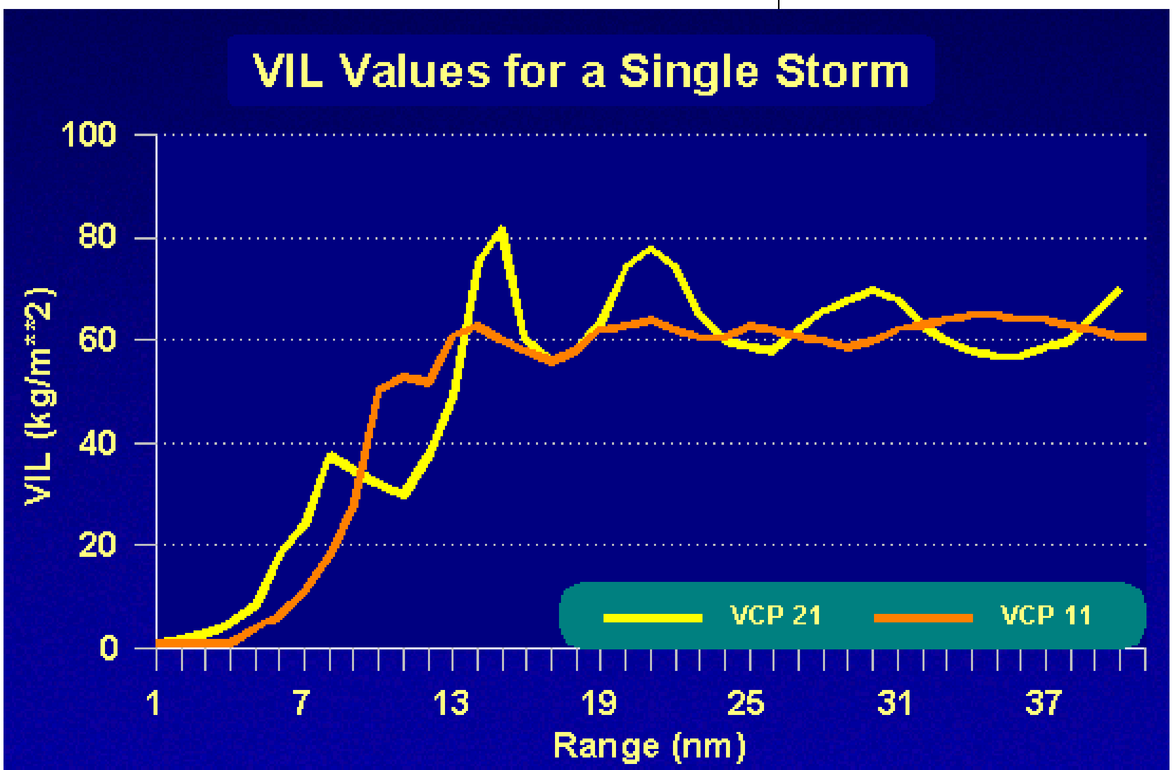


Figure 3-5. This study is from measurements of a single storm using two different volume coverage patterns. The results of the study show that a storm moving toward or away from the RDA will have more fluctuation in VIL values in VCP 21 than in VCP 11. This is due to the fact that there are more gaps in VCP 21 than in VCP 11. This effect is most noticeable within 60 nm of the RDA.

8. Values at distant ranges ($\geq$ 110 nm) are occasionally ***unreliable.*** The reflectivity value at 0.5° is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm producing an overestimation of VIL. With very low- topped convection VIL values may be underestimated at long ranges.

VIL Strengths/ Applications

1. Locate the most significant storms.

High VIL values correspond to deep areas of high reflectivity indicative of strong updrafts. VIL Density (VIL divided by Echo Tops - see Amburn and Wolf (1997)[1]) has also shown some skill indicating significant storms. Limitations of VIL previously listed (e.g., storm tilt and fast moving storms) and Echo Tops (later in this lesson) should always be considered when using these values.

2. Useful for distinguishing storms with large hail once threshold values have been established.

Establishing a VIL of the Day using climatological data and/or sounding data (e.g., see Paxton and Shepherd (1993)[2]) can be of some limited use for initial development, but better skill can be achieved by real-time comparison between VIL values and spotter reports. As with all algorithm output, VIL alone should never be used as a warning criteria.

3. Persistent high VIL values associated with supercells. The exception is mini-supercell thunderstorms or LP Supercells (see Burgess et al (1995)[3]).

4. Rapid decrease in VIL values may signify the onset of wind damage.

Use caution with this technique. It is important to know which VCP is being used because of gaps in the coverage in VCP 21. For more infor-

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[1]Amburn, Steven A., Peter L. Wolf, 1997: **VIL Density as a Hail Indicator.** *Weather and Forecasting*: Vol. 12, No. 3, pp. 473—478.

[2]Paxton, C. H., and J. M. Shepherd, 1993: Radar diagnostic parameters as indicators of severe weather in central Florida. *NOAA Tech. Memo. NWS-SR 149,* 12 pp.

3Burgess, D. W., R. R. Lee, S. S. Parker, D. L. Floyd, and D. L. Andra Jr., 1995:A study of mini supercells observed by WSR-88D radars. Preprints, *27th Conf. on Radar Meteorology,* Vail, CO., Amer. Meteor. Soc., 4—6.

mation see An Overview of Operational Forecasting for Wet Microbursts by William P. Roeder (45th Weather Squadron, USAF Cape Canaveral, FL) on the WDTB Web page

http://www.wdtb.noaa.gov/workshop/psdp/Roeder/index.htm

Reflectivity Cross Section (RCS)

Process

The WSR-88D can generate a cross-section between any two points within a 124 NM range as long as the points are no greater than 124 nm apart.

The cross section product is a volume product created by:

1. ***Linking all elevation scans*** using 0.54 nm base data.
2. ***Interpolating vertically between elevation angles*** where no data are collected (vertical resolution 0.27nm).
3. ***No extrapolation is performed from highest or lowest elevation angle.*** It uses beam center point height.

Cross section products are not recommended for RPS List since endpoints change constantly.

Product Request

Using Interactive Lines, the user places a line through a storm of interest. Lines are referenced by the letters assigned to the endpoints, e.g. A & A’, B & B’, etc. The RCS requires a full volume scan of data, it is generated using data from the last completed volume scan. See Figure 3-6 for an example of the request screen for the RCS product.

Product Interpretation

The user selects 2 points (AZRANS) which can be up to 124 nm apart, but within 124 nm of the RDA. On the cross section product, ENDPT1 is always on the left side, ENDPT2 is on the right. It doesn't matter in which order they are picked. ENDPT1 is defined as the western most point picked, unless along the same longitude, then ENDPT1 is the northern point. The RCS is created using data from the last completed volume scan.

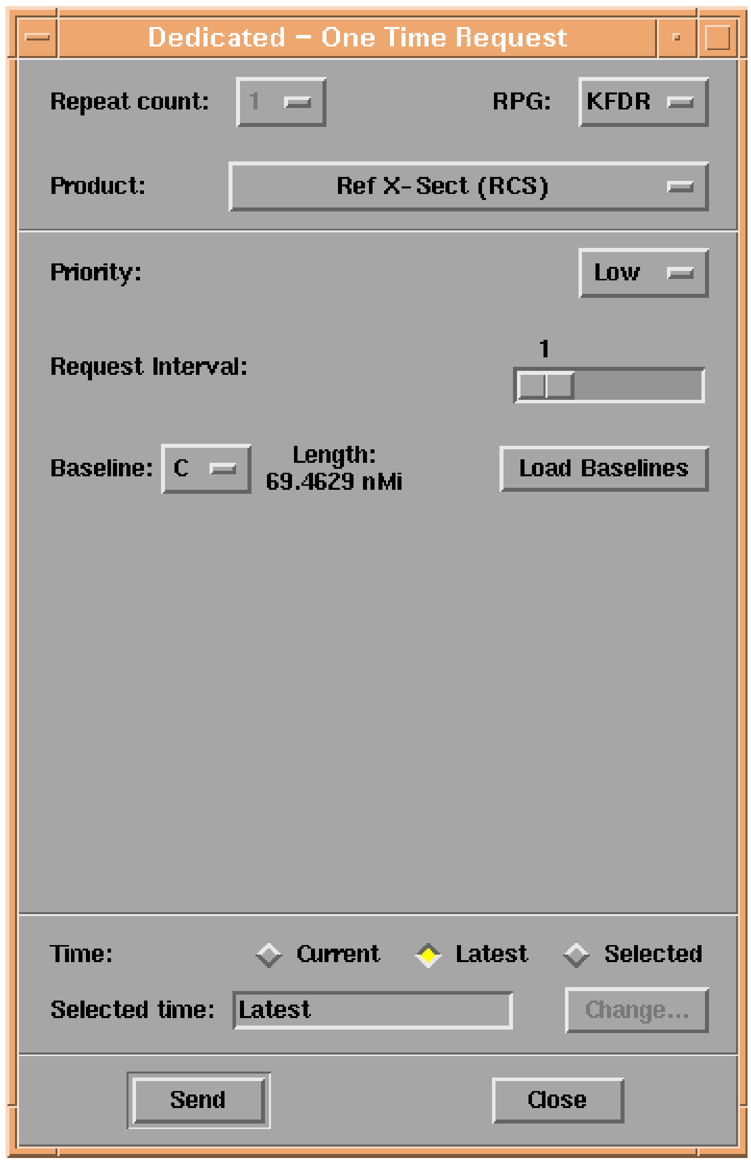


Figure 3-6. RCS product request screen

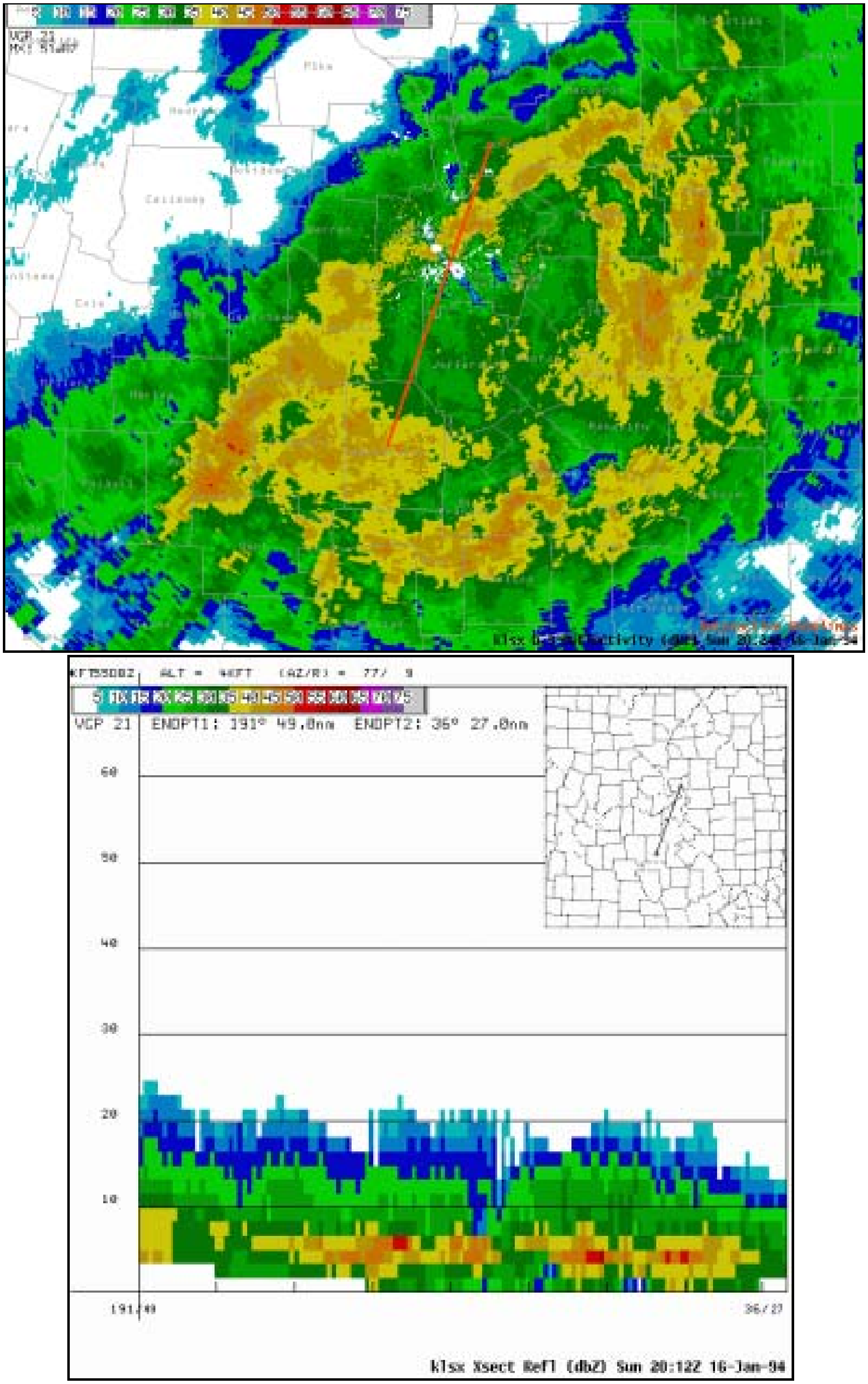


Figure 3-7. Top: Base Reflectivity overlaid with the interactive line used to generate the cross section. Bottom: Matching Reflectivity Cross Section

Product dimensions

- Height on Z axis is at 10,000 ft intervals (Above Radar Level (ARL)), which cannot be changed.
- Range on X/Y axis depends upon length of cross section. Endpoint AZRAN (Azimuth/Range) are listed in the annotations area and on the bottom of the cross section.

Reflectivity Cross Section (RCS) Parameters

See Figure 3-7 for an example of the RCS product.

RCS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Xsect Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

RCS product annotations

- VCP: 11, 21, 31 or 32
- ENDPT1: This is the AZRAN of the westernmost point.
- ENDPT2: This is the AZRAN of the easternmost point.
- MAX (dBZ), ALT (Kft), (AZ/R): Max reflectivity in the cross section, its altitude and AZRAN.

Reflectivity Cross Section Limitations

1. ***Cross section placement may hamper evaluation of storm structure.***
2. ***Echo tops and bases are truncated,*** no vertical extrapolation on the highest or lowest elevation angles.
3. ***Height vs. range exaggeration.*** The vertical extent of the product is 70,000 ft (~11.5 nm), while maximum range is 124 nm.

4. ***Small features may be enlarged or missed due to interpolation.***

5. ***Presentation of product dependent upon VCP. More coarse with VCP 21 than VCP 11.*** Due to more gaps within 60 nm of the radar in VCP 21.

6. ***Fast moving storms may appear to be strongly tilted.*** Because of the time needed to complete a volume scan.

Reflectivity Cross Section Strengths/ Applications

1. ***Detect the vertical extent of clouds/insects/smoke plumes***.

2. ***Verify existence and location of a bright band.***

3. ***Estimate height of higher dBZ's.*** Placement is critical when attempting to estimate dBZ heights.

4. ***Evaluate storm structure features.*** Again, placement is critical in order to see features such as BWERs, WERs, and storm tilt.

5. ***Estimate echo tops.*** This product will display reflectivities down to 5 dBZ in precipitation mode.

6. ***Monitor the formation/dissipation of precipitation events.***

Interim Summary

Vertically Integrated Liquid (VIL)

1. Knowledge of the meteorological environment is necessary to use product effectively.
2. Alerts operator to most significant storms.
3. Effective for detecting storms with 3/4 inch or larger hail.
4. Critical threshold values must be established for differing climatological regions.

Reflectivity Cross Section (RCS)

1. Placement is critical to interpretation.
2. Determine storm structure features such as updraft flank, tilt, storm top, WERs, BWERs, and the vertical extent of higher reflectivities.
3. Cross sections must be within 124 nm of radar with a maximum length of 124 nm.

Composite Reflectivity (CR)

The CR product displays the highest reflectivity for each grid box for all elevation angles.

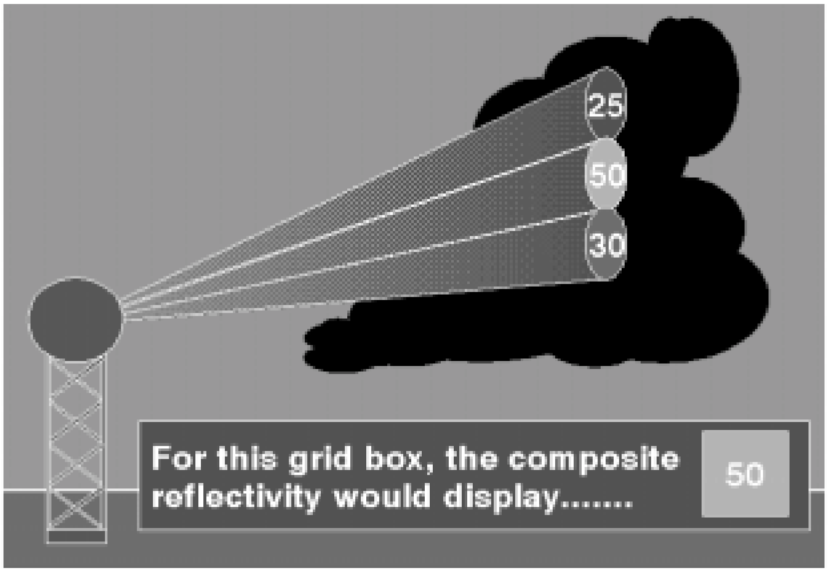


Figure 3-8. Composite Reflectivity

Resolution

- 1 km x 1 km (.54 x .54 nm) range 124 nm
- 4 km x 4 km (2.2 x 2.2 nm) range 248 nm

Note: There is *no 2 km (*1.1 nm) resolution product

The CR product is effective for detecting higher reflectivities aloft.

Combined Attribute Table

The Combined Attribute Table is only available on the Composite Reflectivity (See Figure 3-9). The table contains output from the following algorithms:

1. SCIT

2. HDA

3. TVS

4. MESO

STORM/ID	AZ/RAN	TVS	MESO	POSH/POH/MX SIZE	VIL	DBZM HT	TOP	FCST MVMT
S0	357/ 62	NO	YES	70/100/ 1.25	46	59 18.5	32.7	238/ 29
A0	181/ 90	NO	NO	100/100/ 2.50	62	66 20.0	37.7	257/ 33
C3	160/107	NO	NO	80/100/ 1.25	53	61 13.7	35.2	234/ 39
F3	326/ 16	NO	NO	70/100/ 1.25	37	62 15.8	>34.0	NEW

Figure 3-9. Combined Attribute Table which appears at the top of the Composite Reflectivity product.

Some outside users are only able to access TVS and MESO detections using the Combined Attribute Table. This can lead to confusion since the table only includes azimuth and range to the **storm cell centroid**, not the TVS or MESO location.

The Combined Attribute Table includes:

- **STM ID** - Cell ID letter/number
- **AZ/RAN** - Azimuth and Range of **cell centroid**
- **TVS** - Yes if TVS is present or No
- **MESO** - Yes or no for MESO only. It will always be no for 3-D Correlated Shear, or Uncorrelated Shear.
- **POSH / POH / MX SIZE** - Probability of Severe Hail / Probability of Hail / Max Hail Size
- **VIL** - Cell Based VIL
- **DBZM HT** - Maximum reflectivity (dBZ) and height of maximum reflectivity (Kft)
- **TOP** - Height of upper most component (Kft)
- **FCST MVMT** - Forecast movement (deg./ kts)

Order of storms

1. TVS or ETVS
2. Mesocyclone, 3DC Shear, Uncorrelated Shear
3. Probability of Severe Hail (POSH)
4. Probability of Hail (POH)
5. Cell based VIL

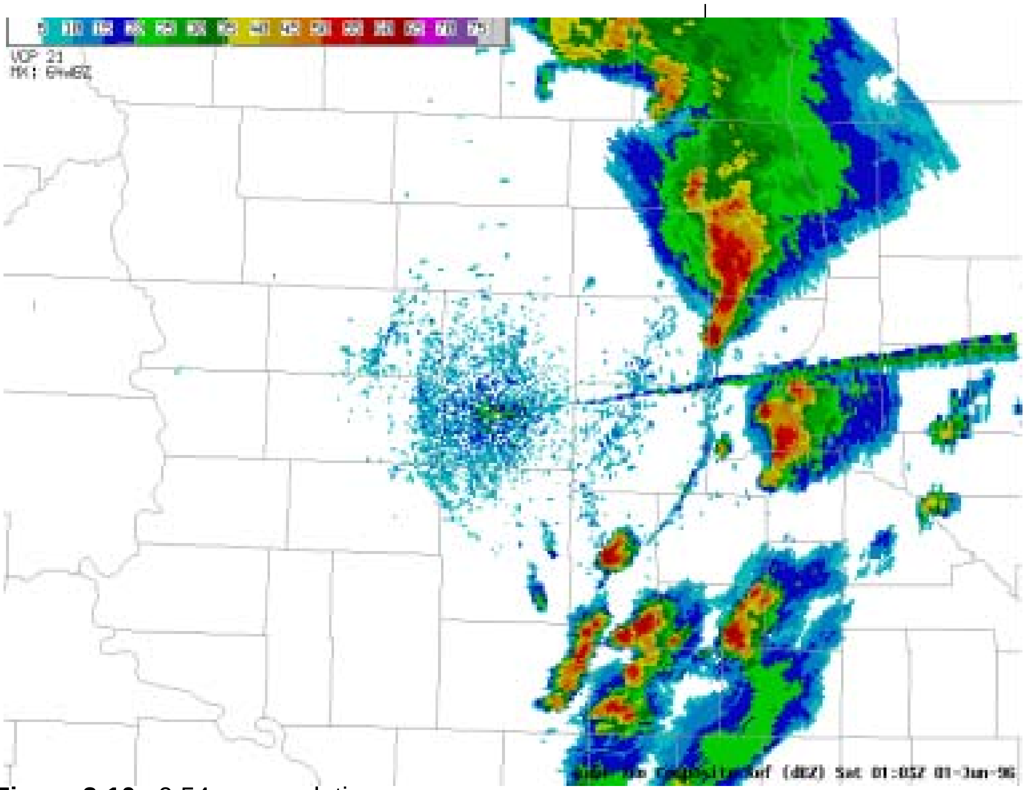


Figure 3-10. 0.54 nm resolution.

Note: Cells with unknown POSH or POH (i.e., cells beyond 124nm), yet high cell based VIL, may end up at the bottom of the Combined Attribute Table.

Composite Reflectivity (CR) Product

See Figure 3-10, 3-11, and 3-12 for examples of the CR product.

CR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Composite Ref
- UNITS: dBZ
- DATE: Day of week, time and date in UTC

CR product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This

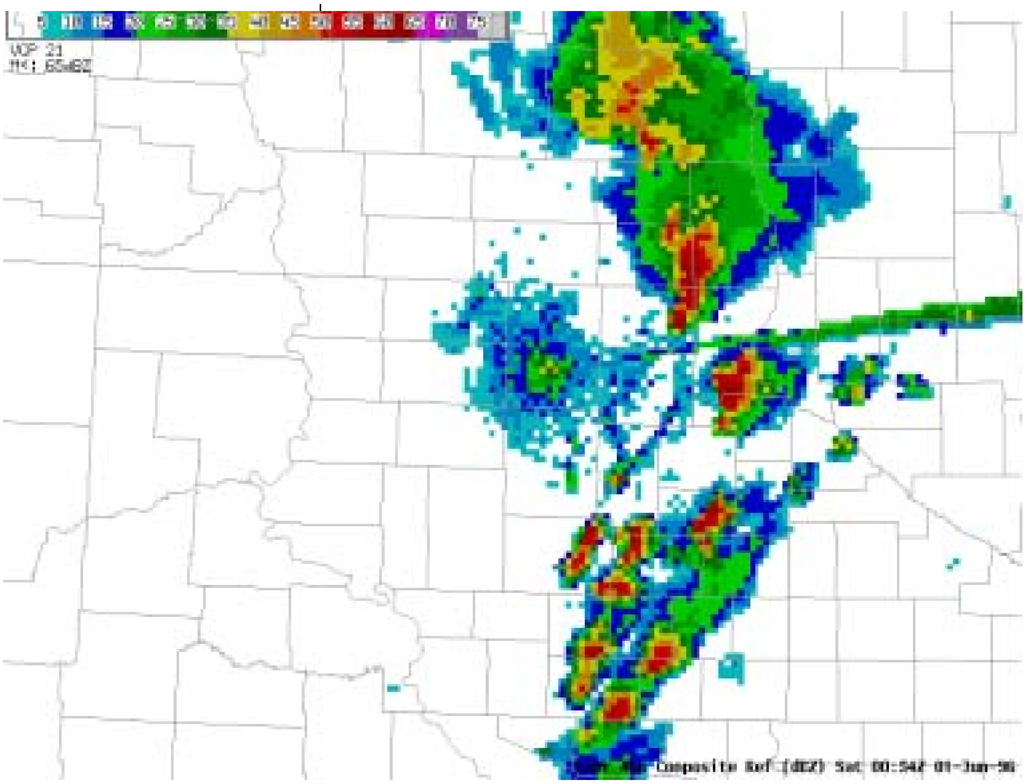


Figure 3-11. 2.2 nm resolution

value will not change when zoomed in on a feature, as it is the maximum value for the entire product.

Additional CR product characteristics

- RANGE: 124 or 248 nm
- RESOLUTION: .54 or 2.2 nm, respectively
- DATA LEVELS: 16 data levels - values range from 5 to 75 dBZ

Composite Reflectivity Limitations

1. **Low level reflectivity signatures are obscured.**
2. **Height of reflectivity is unknown.**
3. **Echo aloft can't be discriminated from precipitation reaching the surface.**
4. **Non-precipitation echoes may contaminate product.**

Figure 3-12. Composite Reflectivity (CR) product showing both resolutions.

Composite Reflectivity Strengths / Applications

1. **Reveals highest reflectivity in all echoes.**
2. **Determine storm structure features & intensity trends in storms.** (When compared with base products).
3. **Generate cross sections through maximum reflectivity knowing the inflow side of storm.** The operator will have more predictable results with a .54 nm product.
4. **The Combined Attribute Table is available.**

Layer Composite Reflectivity Maximum (LRM)

LRM Product Definition

- Displays the highest reflectivity value of all elevation angles for each 2.2 x 2.2 nm grid box in a layer.

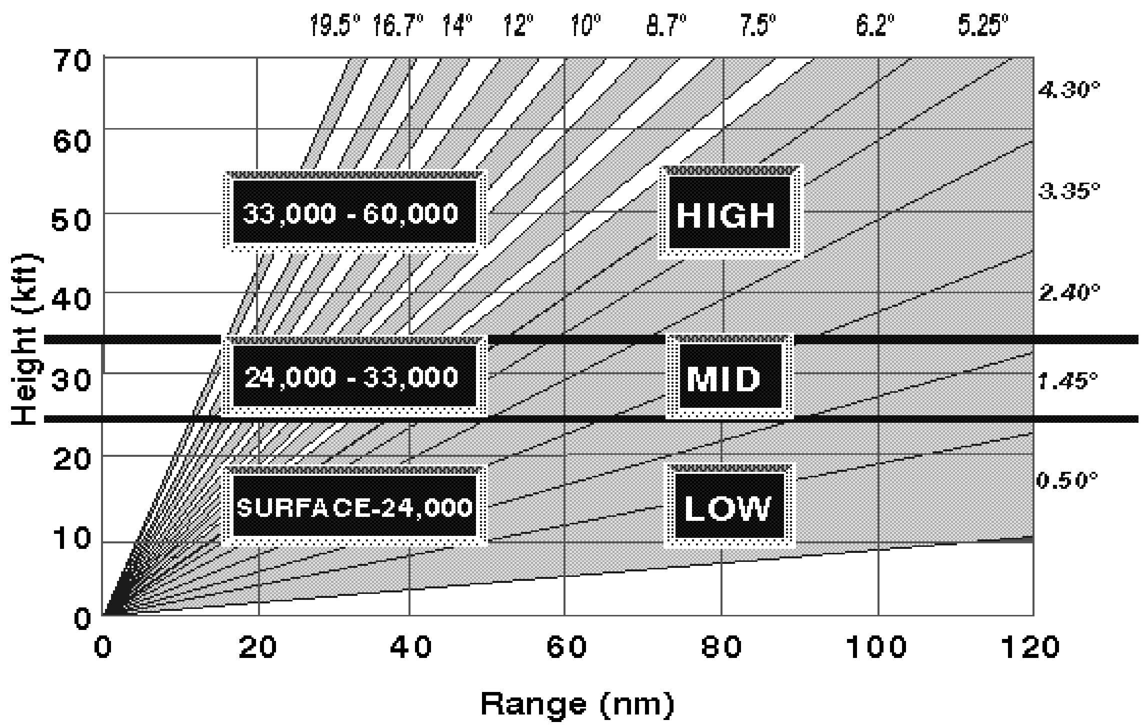


Figure 3-13. Layer Composite Reflectivity Default Layers (VCP 11)

Three layers

- **Low** (Layer 1) **-** User-defined (Sfc - 18K) to 24,000 ft
- **Mid** (Layer 2) **-** 24,000 ft to 33,000 ft
- **High** (Layer 3) **-** 33,000 ft to 60,000 ft With the exception of the base of the lowest layer, no changes can be made to alter the depths of these products. If different layers are desired use the User Selectable Layer Reflectivity (ULR) product described next.

Originally developed for CWSU/FAA use.

Desired product layers (L,M,H) can be specified on the RPS list or one time request.

Resolution 2.2 x 2.2 nm; Coverage **248 x 248 nm**.

Available with **8** data levels only

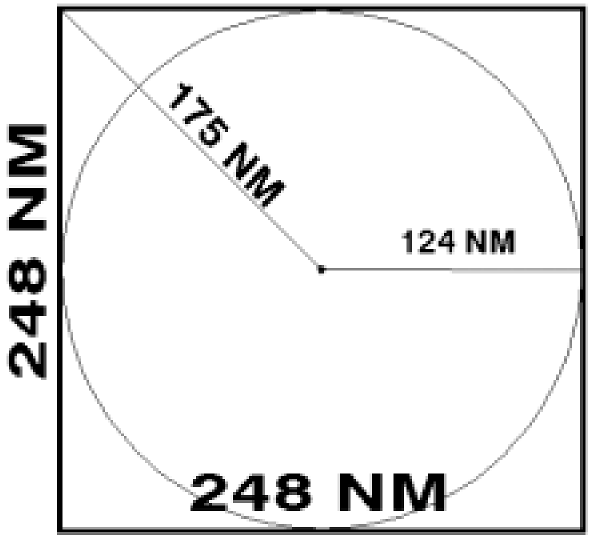


Figure 3-14. LRM/LRA Product size.

LRM Product Parameters

See Figure 3-15 for an example of the LRM product.

LRM product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Layer 1 (2 or 3) Max Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

LRM product annotations

- VCP: 11, 21, 31 or 32
- BOT: Bottom of the layer in kft, which is user selectable (Figure 3-15)
- TOP: Top of the layer in kft, which is fixed at 24 kft.
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a

feature, as it is the maximum value for the entire product.

Additional LRM product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: Data level values are fixed at 5, 18, 30, 41, 46, 50, 57 dBZ

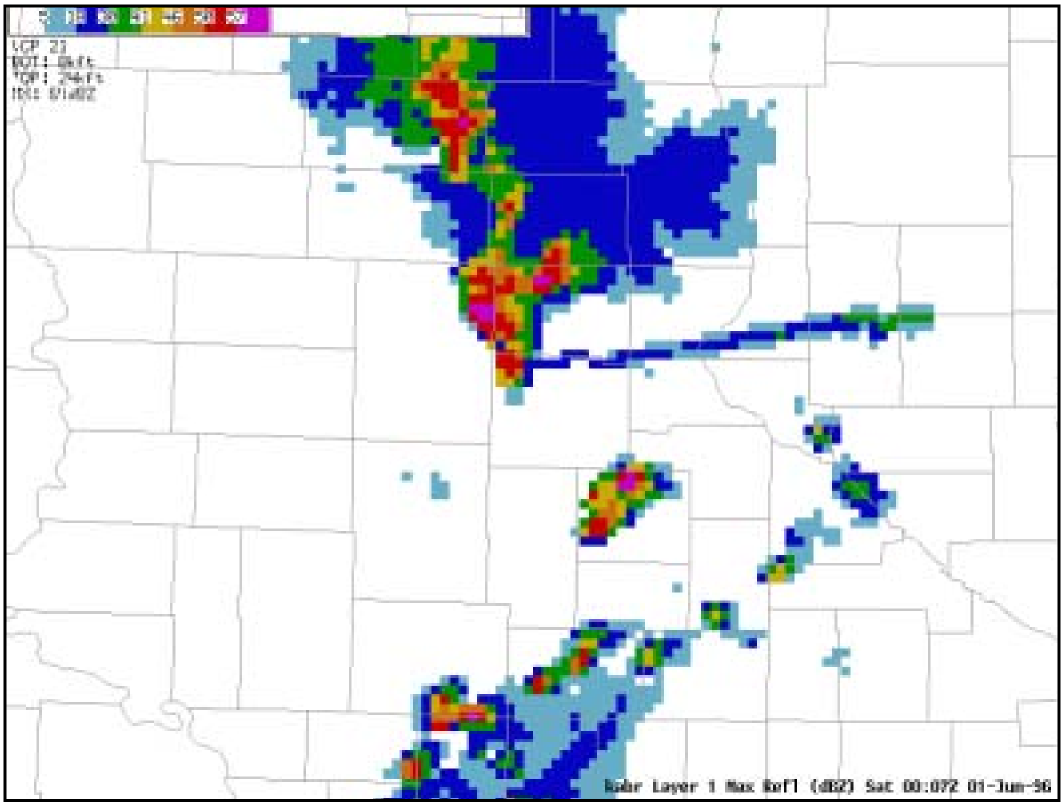


Figure 3-15. Layer Composite Reflectivity Maximum (LRM) product - low layer with base at 8,000 ft MSL.

LRM Limitations

1. Mid & Low layer products will use few elevation angles at long distances.
2. Mid and High level products are ineffective at close range due to the cone of silence.
3. Low layer product susceptible to non-precipitation echoes.

LRM Strengths/ Applications

1. Mid-High layer products used to estimate the height of higher reflectivities.
2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.
3. Use mid level product to help differentiate real echoes from ground clutter.

User Selectable Layer Reflectivity Maximum (ULR) Product

Introduction

The addition of the User Selectable Layer Reflectivity Maximum (ULR) product in RPG Build 3 and AWIPS Build OB1 allows the user to select a specific, customized layer of reflectivity. The ULR offers the capability for the user to select both the lower and upper levels to design a product which will meet various forecasting needs such as a better understanding of storm structure and potential levels of icing (Bright Banding).

ULR Product Characteristics

The minimum thickness of the selected layer is 1 kft and altitudes from 0 to 70 kft may be selected. The ULR is a polar gridded product (note the LRM and LRA products are rectangularly gridded). The ULR's resolution is 1 km (.54 nm) x 1° and has a range of 230 km (124 nm). The Layer Composite Reflectivity task allows up to 10 layers per volume scan. This is 10 for all users, not 10 per user. Non-associated Users can only get previously generated products by doing one-time requests.)

See Figure 3-17 for an example of the ULR product.

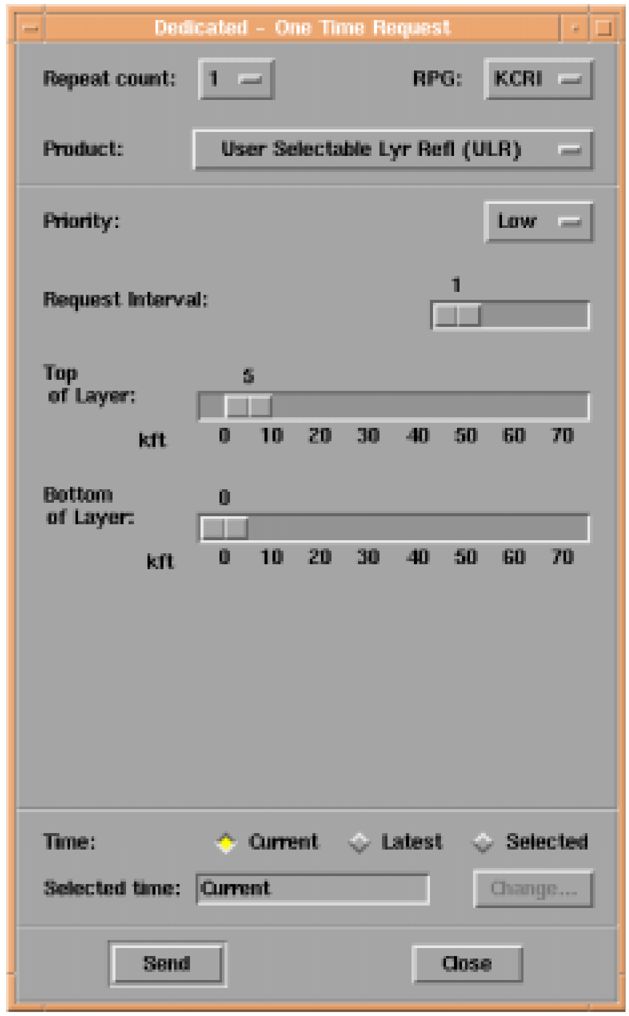


Figure 3-16. User Selectable Layer Reflectivity Maximum (ULR) One Time Request Window.

ULR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: User Selectable Refl
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

ULR product annotations

- VCP: 11, 21, 31 or 32

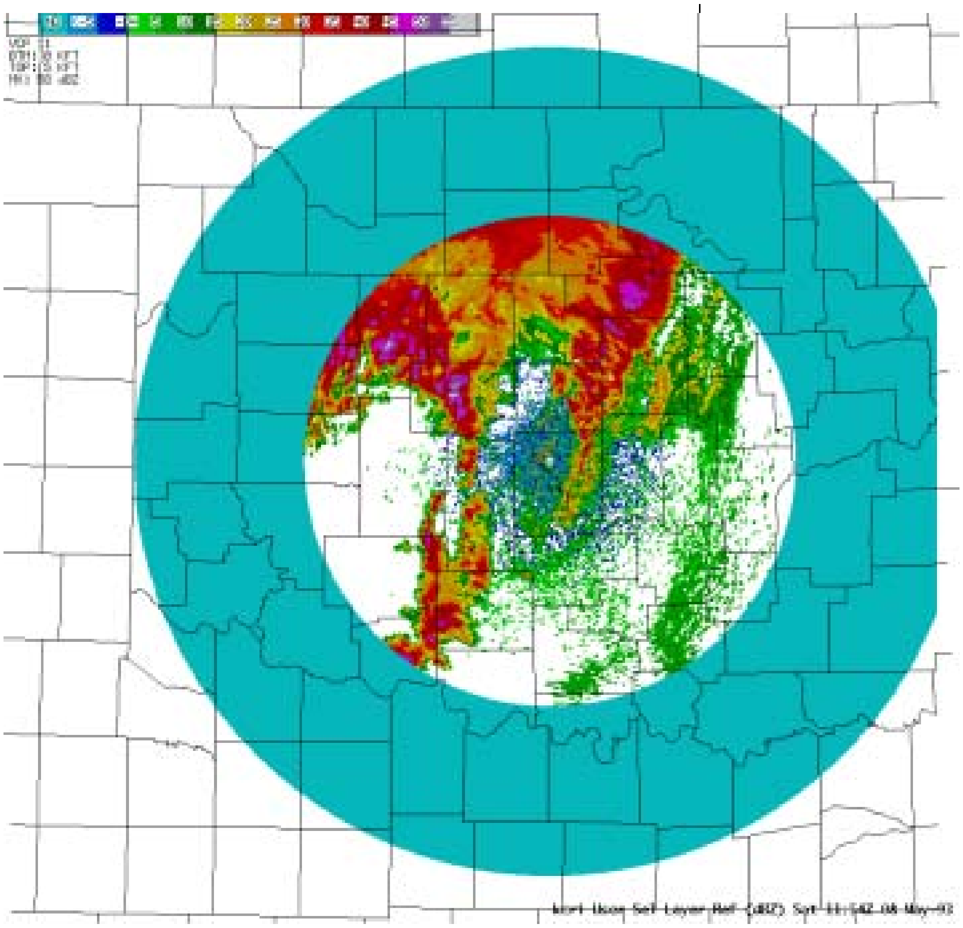


Figure 3-17. User Selectable Layer Reflectivity (ULR) product

- BOT: Bottom of the layer in kft
- TOP: Top of the layer in kft
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the maximum value for the entire product Additional ULR product characteristics
- RANGE: 124 nm
- RESOLUTION: 1° x 0.54 nm
- DATA LEVELS: 16 data levels

ULR Limitations

1. Height of data within selected layer is unavailable.
2. Shallow layers will often have concentric circles (stepped appearance) due to sampling (limited elevation angles through layer).

ULR Strengths

1. Layer can be selected to meet user needs.
2. Has higher resolution and more data levels than LRM products.
3. Can be used to locate bright band.

LRM - Anomalous Propagation Removed (APR) Product

Introduction

The Layer Composite Reflectivity Maximum - Anomalous Propagation Removed product (APR, ID# 67) is an 8-data level reflectivity display similar in appearance to the Layer Composite Reflectivity Maximum (LRM) Low Layer (Layer 1). It is derived from the output of an algorithm which processes base reflectivity, velocity, and spectrum width data with the goal of distinguishing between meteorological returns and returns from ground clutter/AP. The algorithm will generate a Surface to 24,000 ft Layer Composite Reflectivity Maximum product every volume scan with the algorithm-identified ground targets removed.

APR Algorithm

The algorithm used to identify and remove clutter is based on the observation that ground targets tend to affect mainly the lowest antenna tilts, and are typically associated with low radial velocity and low spectrum width.

The algorithm separates the reflectivity data into four regions based on distance from the RDA, and altitude above the surface. A different clutter removal technique is applied to each region, based on known observations of the appearance and location of clutter.

The ***Omit All*** region is defined as that portion of the atmosphere within 45 km of the RDA, and below 1 km in altitude. All targets in the *Omit All* region are considered clutter and are removed (see Fig. 3-18).

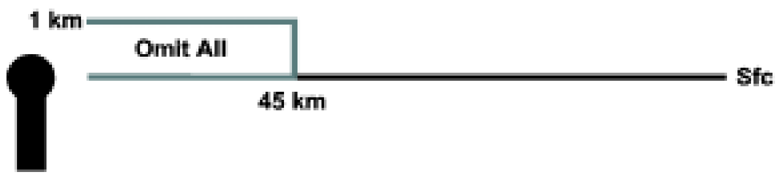


Figure 3-18. Omit All Region.

The ***Accept If*** region is defined as data that is on the 0.5° elevation slice within 103 km of the RDA (below 3 km in altitude), and not within the Omit All region. A target in the *Accept If* region is displayed if its velocity is $\geq$ 2.0 m/s ***and*** its spectrum width is $\geq$ 2.0 m/s. Essentially, a target in this region is assumed to be clutter, but it will be ***accepted*** as being meteorological ***if*** movement is indicated by velocity and spectrum width data (see Fig. 3-19).

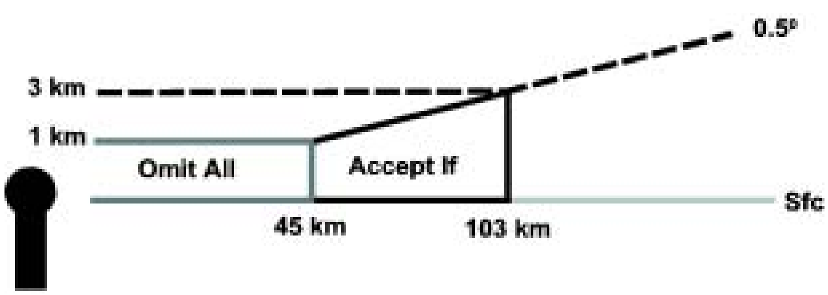


Figure 3-19. Accept If Region.

The ***Reject If*** region is defined as that portion of the atmosphere within 230 km of the RDA, below 5° in elevation, and not within either the Omit All or Accept If regions.

A target in the *Reject If* region is rejected if it possesses a velocity < 2.0 m/s and a spectrum width < 2.5 m/s. Essentially, a target in this region is assumed to be meteorological, but it will be ***rejected*** as being clutter ***if*** little or no movement is indicated (see Fig. 3-20).

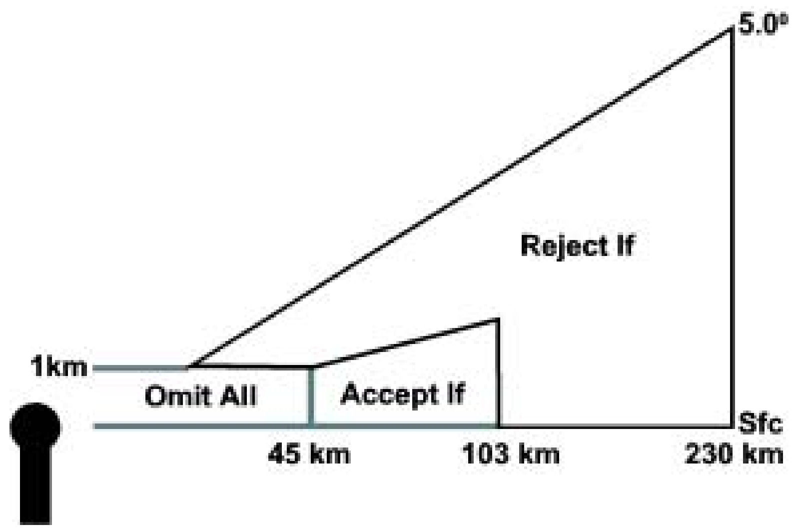


Figure 3-20. Reject If Region.

All other data are accepted as in the LRM Low Layer product.

LRM - AP Removed Product Parameters

See Figure 3-21 for an example of the APR product.

APR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Layer Max Refl--No AP
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

APR product annotations

- VCP: 11, 21, 31 or 32
- BOT: Bottom of the layer in kft, which is fixed at the surface
- TOP: Top of the layer in kft (fixed at 24 kft)
- MX: This is the maximum reflectivity (dBZ) on the product, with the location unknown. This value will not change when zoomed.

Additional APR product characteristics

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: 8 Data levels - values range from 5 to 57 dBZ

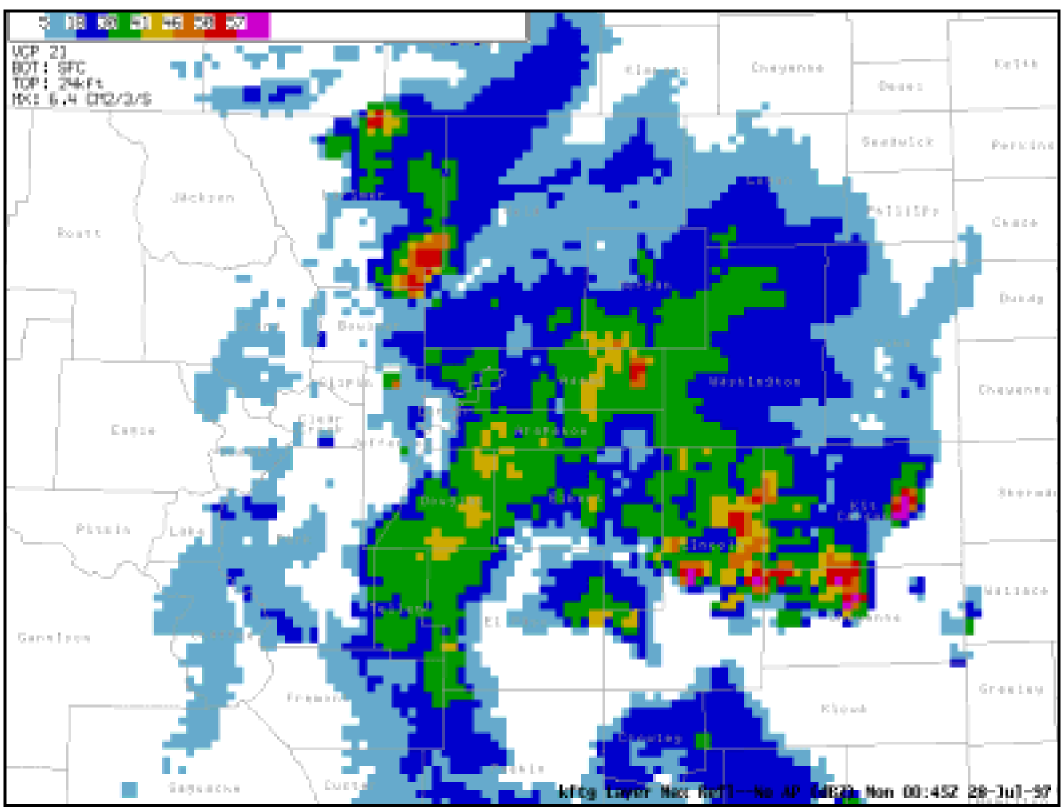


Figure 3-21. LRM-AP Removed product.

APR Limitations

1. The algorithm works best if traditional clutter filtering is applied before the algorithm begins processing data.
2. The algorithm assumes ***all*** low level data within 45 km of the RDA and below 1km above radar level (ARL) is clutter, which may result in valid data being dropped from the product.

APR Strengths

The APR algorithm attempts to distinguish weather targets from clutter targets.

Interim Summary

Composite Reflectivity (CR)

1. Displays the maximum reflectivity for each vertical resolution grid box.
2. Useful product to:
   - quickly identify most intense storms, &
   - determine where to create Reflectivity Cross Sections.
3. Combined Attribute Table is available with product.

Layer Composite Reflectivity Maximum (LRM)

1. Maximum reflectivity for a specified layer.
2. Mid or high layer product used to estimate height of higher reflectivities
3. Comparison of mid or high layer products and Base Reflectivity may help determine the intensity trend of storms.

User Selectable Layer Reflectivity (ULR)

1. Layer can be selected to meet user needs, such as bright band detection.
2. Has higher resolution and more data levels than LRM products.

LRM - Anomalous Propagation Removed (APR)

1. Attempts to distinguish weather targets from ground targets.
2. Algorithm works best if traditional clutter filtering is applied.

Echo Tops (ET)

Definitions

Top - Height of highest component

Cloud Top - Height of the lowest displayed reflectivity (5 dBZ)

Echo Top - Height of the 18.3 dBZ echo

The Echo Top product locates the highest elevation angle where ***reflectivity ≥ 18.3 dBZ*** for each ***2.2 x 2.2 nm grid box.***

Only available resolution is 2.2 x 2.2 nm.

The Echo Top algorithm measures height where reflectivity is ≥ 18.3 dBZ, then MSL height of RDA is added to echo top height.

A ***circular stair-stepped appearance*** can occur since the beam center point is used to measure the height. This is usually most noticeable with widespread precipitation at distant ranges.

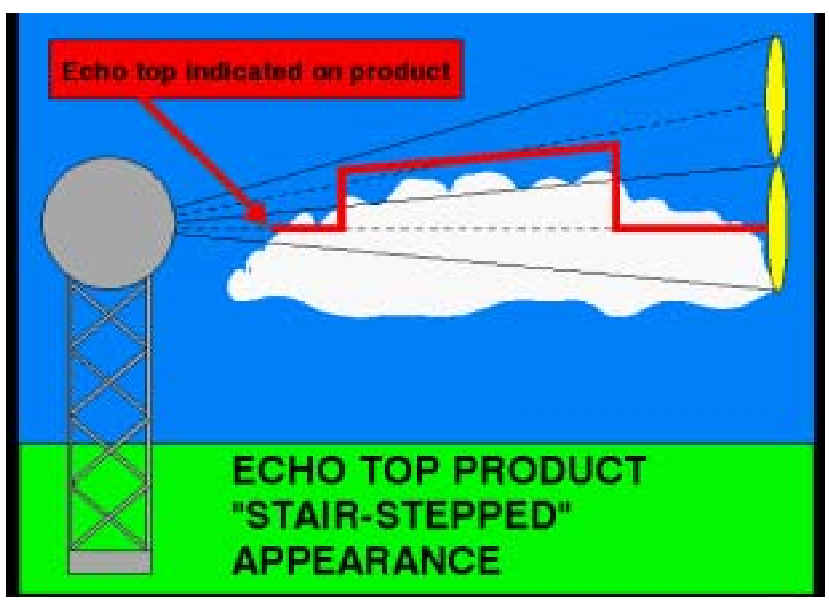


Figure 3-22. Echo Top product stair-stepped appearance.

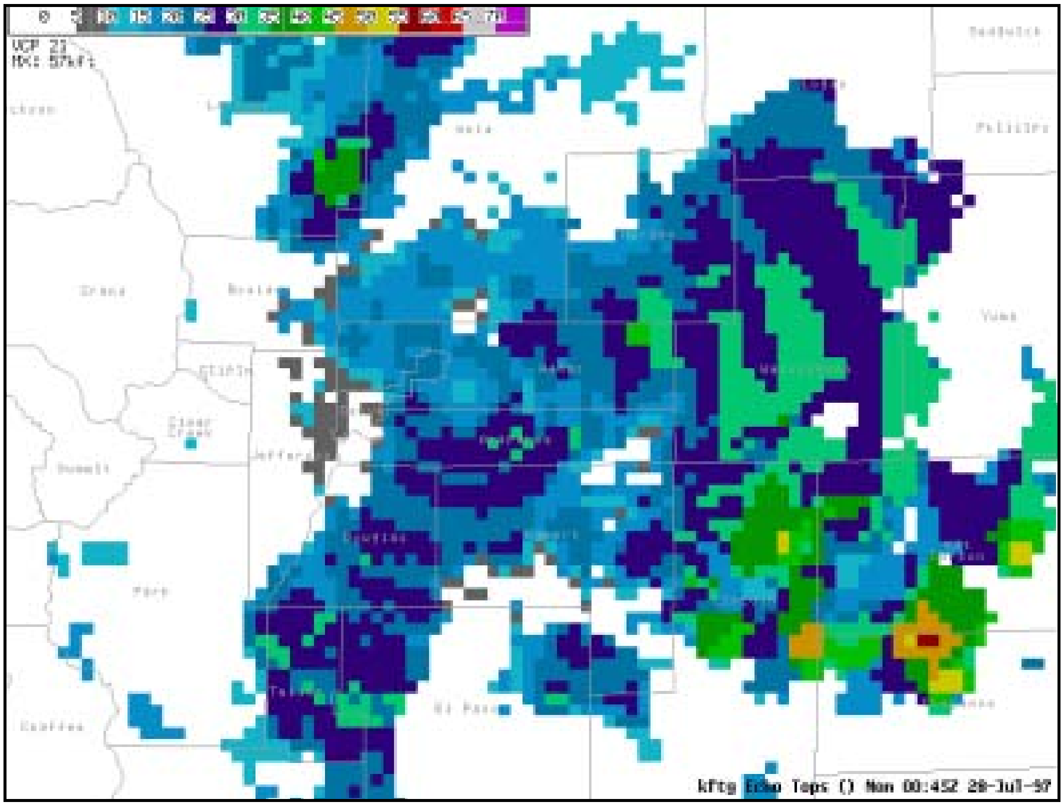


Figure 3-23. Echo Top (ET) product

Echo tops will vary from cell tops because the SCIT algorithms use the height of the upper most component (ARL). Echo tops uses reflectivities $\geq$ 18.3 dBZ (MSL) which corresponds to the minimum detectable echo on earlier radars (WSR-57S and WSR-74C).

Echo Tops Product Parameters

See Figure 3-23 for an example of the ET product

ET product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Echo Tops
- UNITS: kft
- DATE: Day of week, time, and date in UTC

ET product annotations

- VCP: 11, 21, 31 or 32
- MX: This is the maximum height (kft) on the product, with the location unknown. This value will not change when zoomed in on a feature, as it is the max value for the entire product.

Additional ET product characteristics:

- RANGE: 124 nm
- RESOLUTION: 2.2 x 2.2 nm
- DATA LEVELS: 16 Data levels - values range from 5 kft to 70 kft

Echo Tops Limitations

1. **A circular stair-stepped appearance will often be evident** due to use of beam center-line.
2. No upward extrapolation from the last elevation angle where precipitation was detected.
3. Side lobes may result in overestimated tops.
4. Tops will be underestimated close to the radar due to the cone of silence.
5. Difficult to locate the highest echo top in a storm due to lack of upward vertical extrapolation, and heights are displayed in 5000 ft increments. (See Fig. 3-24 on page 73.)

Echo Tops Strengths/ Applications

1. **Quick estimation of the most intense convection**; higher echo tops.
2. Assist in differentiating non-precipitation echoes from real storms.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
4. May detect mid-level echoes before low-level echoes are detected.

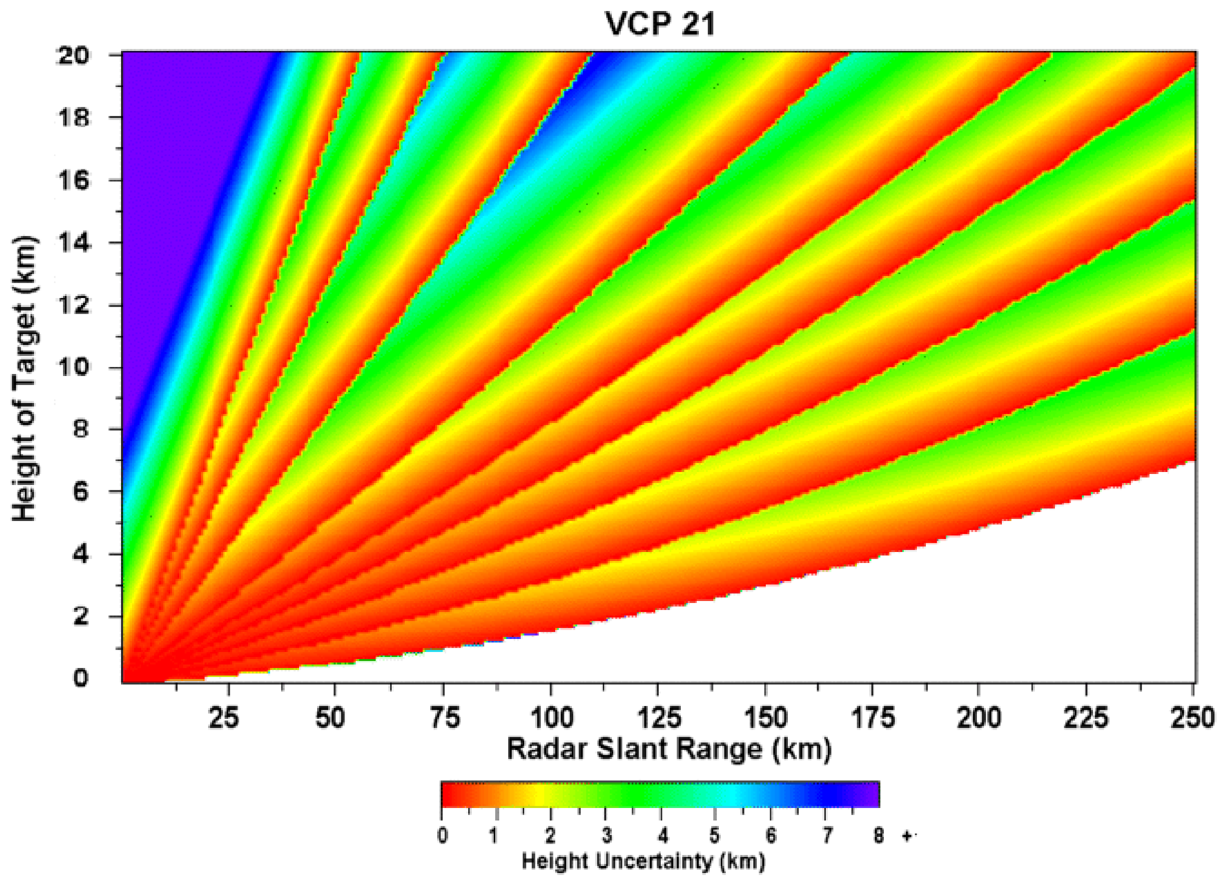


Figure 3-24. Height uncertainty as related to elevation angle.

Interim Summary

Echo Tops Product

1. Measures height of ≥ 18.3 dBZ echo; height in MSL using the beam center point altitude.
2. Primary use of product is to identify storms with greater vertical development.
3. Aid in differentiating real echoes from non-precipitation echoes.

Lesson 4: Velocity Based Algorithms and Products

Overview

Velocity Derived Products are those which use the Base Velocity Data as their primary input. The benefit of these algorithms is that they quickly analyze the entire volume scan of velocity data and give the operator guidance as to which areas need additional investigation. Keep in mind that the Base Velocity Data used in these algorithms has already undergone dealiasing as well as range-unfolding before being ingested. As a result, problems such as dealiasing failures or range folding will occasionally make it more difficult for the Velocity Derived Algorithms to produce accurate information

Review

The WSR-88D measures only radial velocity.

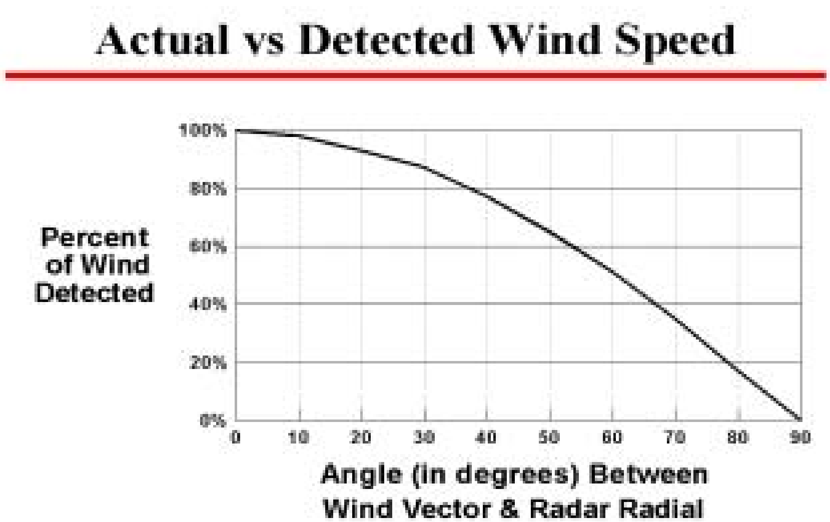


Figure 4-1. If the wind direction is directly down the radial, 100 percent of the velocity will be measured. If it is blowing perpendicular across the radial, 0 percent will be measured. Always keep this in mind when estimating wind speed from Doppler velocities.

Knowledge of where the RDA is in relation to the feature is also very important for proper interpretation. Use of the Polar Grid background map may help the operator to locate the radar when magnification is done.

Here is a quick review of some small scale signatures and their positions relative to the radar. Notice how the signatures look the same, but because the are in different locations relative to the radar, they would be interpreted differently.

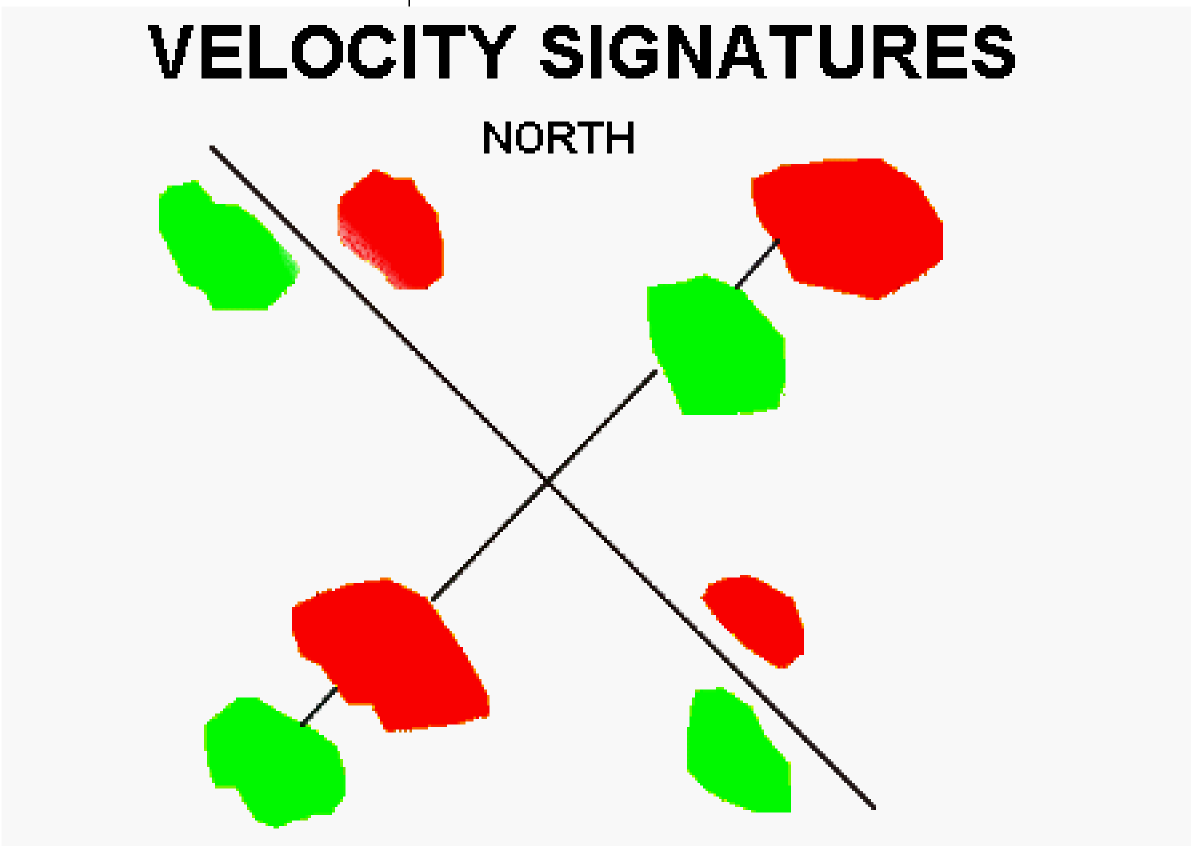


Figure 4-2. Small scale signatures.

Objectives

Without references and according to the lesson, you will be able to identify one strength and one limitation of the following velocity products:

1. Storm Relative Mean Radial Velocity Map (SRM)
2. 8-Bit SRM
3. Storm Relative Mean Radial Velocity Region (SRR)

4. Velocity Cross Section (VCS)

5. Velocity Azimuth Display (VAD)

6. Velocity Azimuth Display Wind Profile (VWP)

7. Mesocyclone (M)

8. Mesocyclone Rapid Update (MRU)

9. Tornadic Vortex Signature (TVS)

Storm Relative Mean Radial Velocity Map (SRM)

SRM Overview

A long name which will be shortened to SRM from here on out! The SRM is a 124 nm radius product of mean radial velocity with an estimated storm motion subtracted out.

In the example (See Fig. 4-3 on page 78.), the identical mesocyclone is displayed using a Base Velocity product (left) and the SRM Product (right). The storm is moving to the northeast at 40 kts. The Base Velocity is measuring both the circulation and the storm motion. Therefore, all we see is outbound velocities (much stronger on the right side of the couplet). In the SRM, we take away the motion of the storm itself, leaving only the circulation. The couplet is now very apparent to the observer showing the classic signature for pure rotation. Unless you are very experienced, you might not suspect a circulation is present using base velocity alone. However by looking at the SRM, you can now take steps to evaluate the strength of the circulation and determine a course of action.

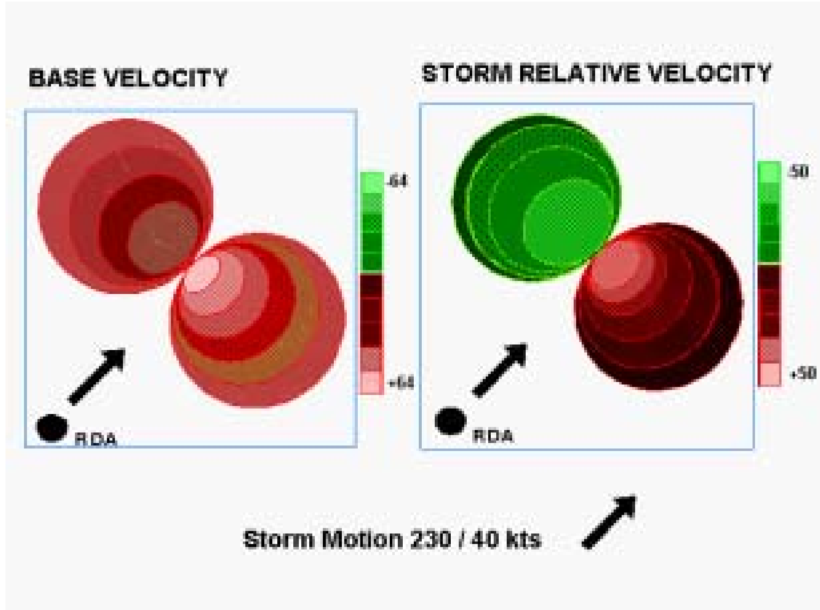


Figure 4-3. When storm motion is subtracted, circulations are easier to see.

Default Storm Motion

Estimated storm speed and direction used by the algorithm will default to the ***average motion of all storms*** from the Storm Track Information Product (from the previous completed volume scan). Keep in mind the limitations of the SCIT algorithm which can cause erroneous storm motions to be generated. If these errors occur, they will be passed along to this algorithm.

Operator Input Storm Motion

To override this, speed and direction can be input by an AWIPS operator on a one-time request basis to an associated RPG. The Repeat Count Function may be used. Only SRMs with the default motion subtracted can be received from Non-associated RPGs.

Note: The One-Time Request window is used to input operator defined motions for the standard (4-bit) SRM products. A different window or Graphical User Interface (GUI) is used to input a user defined motion for the 8-bit SRM covered next.

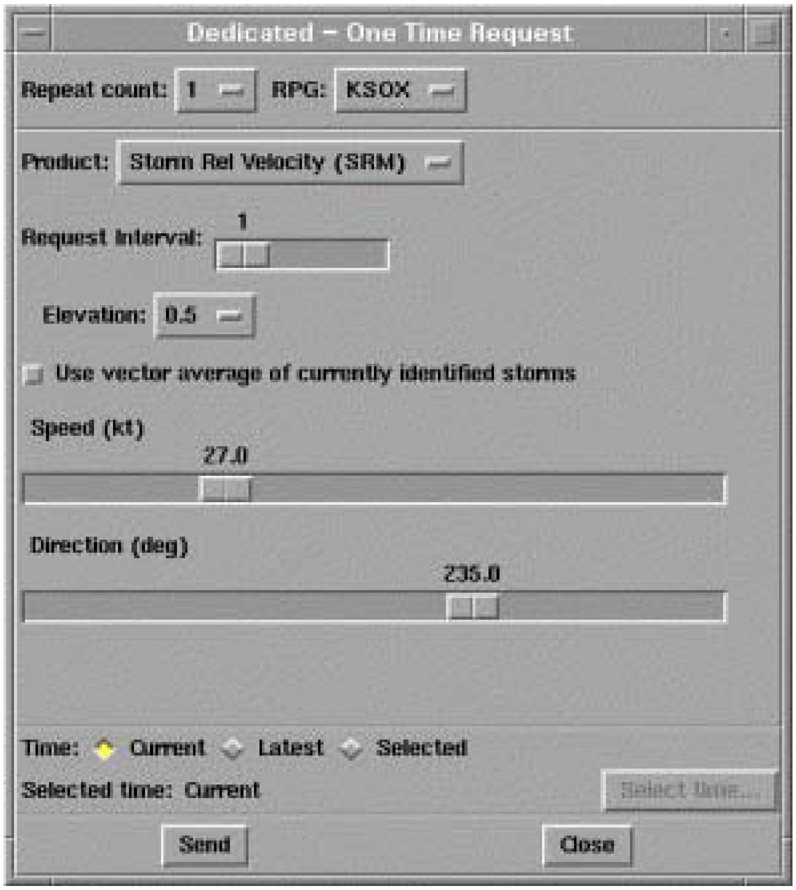


Figure 4-4. Operator input storm motion of 235° at 27 kts.

SRM vs. Base Velocity

Vector subtraction of estimated storm speed and direction is made from every 0.13nm base velocity range gate to a radius of 124nm. The SRM displays the ***maximum*** value of every four 0.13nm range bins in each 0.54nm range gate. Recall that the 0.54nm resolution Base Velocity uses the ***first*** of every four 0.13nm range bins. This means that velocities may appear stronger on the SRM than for the same range bin on the 0.54nm Base Velocity.

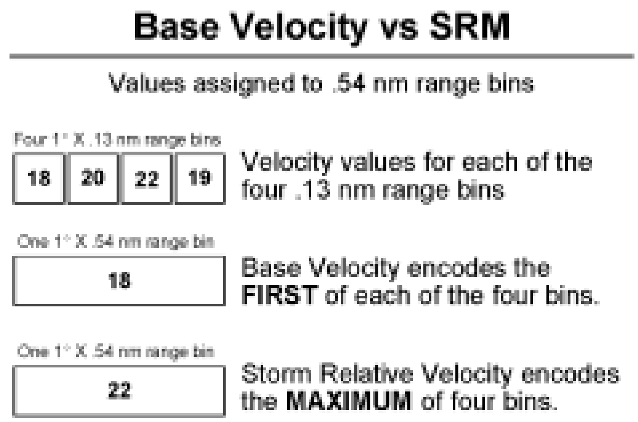


Figure 4-5. Base Velocity vs. SRM value. (Storm motion is 0/0 in this example.)

Product Uses

SRM is useful in detecting shear regions

1) Mesocyclone

2) TVS

3) Upper level divergence

****What feature are you attempting to see?*** When using Storm Relative products you should always consider your frame of reference. If you are interested in the rotation within a storm, use Storm Relative products. If you are interested in ground relative winds, (i.e., winds associated with a gust front) use the base velocity products.

Product Description

SRM product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

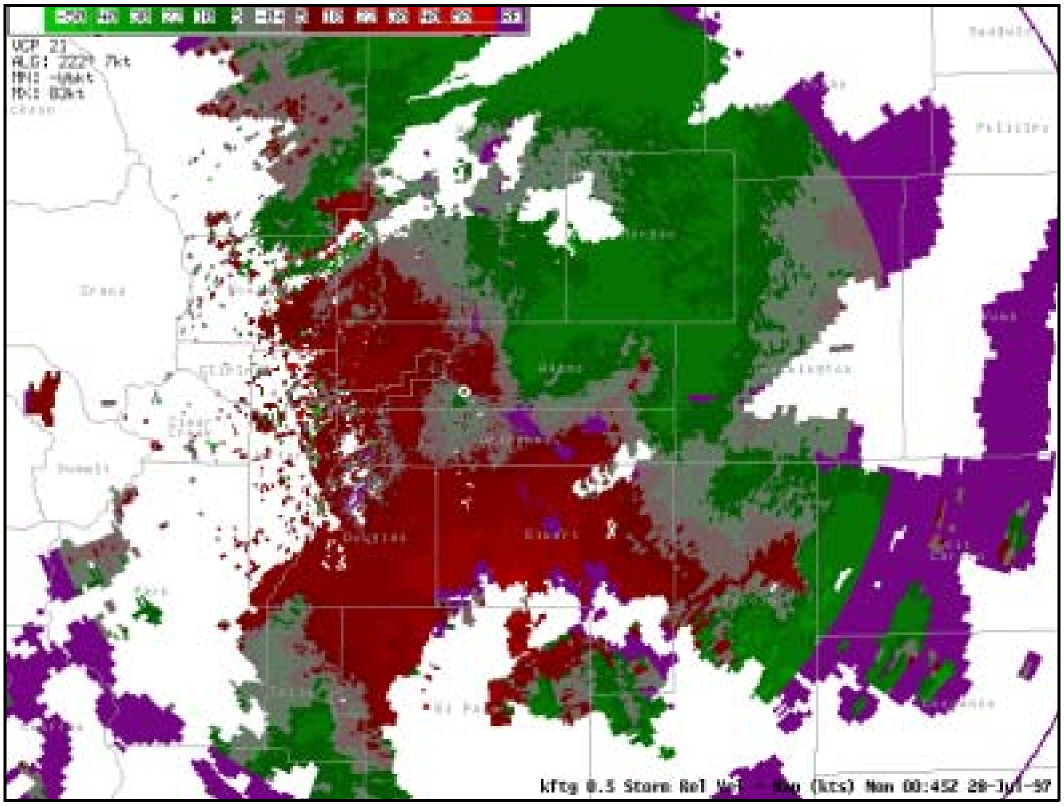


Figure 4-6. Storm Relative Mean Radial Velocity Map (SRM) product

SRM product annotations:

- VCP: VCP 11, 21, 31 or 32
- ALG: This is the default storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- USR: This is the user supplied storm motion which has been subtracted out. The direction in degrees and speed in kts.
- MN: This is the strongest inbound (negative) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.
- MX: This is the strongest outbound (positive) velocity detected on the product. The location of this value is unknown, and this is a Storm Relative value.

Additional SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS:
    - 16 data levels from -50 kts to +50 kts, with one level (usually purple or white) for range folded data.
    - Data levels cannot be changed on the SRM.
    - Data levels are ***lower bound***. (For example, 22 kt data level can range from 22-29 kts.)

To investigate a storm three-dimensionally, it is recommended that you put at least 4 elevation cuts on your RPS List to be viewed in a 4-panel presentation or several slices to be viewed in the all tilts mode. The slices you choose should be the same as those selected for Base Reflectivity products on your RPS List. The angles you choose will of course depend on the vertical extent of the storm as well as the range to the storm. However, it is always advisable to have a 0.5° Base Velocity on the RPS list to determine ground-relative winds.

SRM Limitations

1. Storm Relative flow will be inaccurate if the storm motion subtracted isn't representative of the storm being investigated.
2. More difficult to determine actual ground-relative winds.
3. Average Storm Relative motion likely will vary from volume scan to volume scan. SCIT computes the average storm motion each volume scan, so strong rotation on one scan may not be as obvious on the next scan. This could really be due to a change in the average storm

motion used as input, rather than the storm actually changing.

SRM Strengths/ Applications

1. Used to investigate the 3-D velocity structure of a storm when used in a 4 panel
2. Most useful with faster moving storms (> 10 kts)
3. Operator may input storm motion at AWIPS (One Time Request--Repeat Count).

8-bit SRM

Process

The 8-bit (256 data level) SRM is a display produced “on-the-fly” by AWIPS using data from the 8-bit Base Velocity product. The 8-bit SRM is not a product produced by the RPG, therefore it is not archived as such. To obtain an 8-bit SRM product you must first have the corresponding 8-bit Velocity product in the AWIPS data base, by either including the 8-bit Velocity on the RPS list or by One-Time Request.

The 8-bit SRM storm motion can be set three ways:

1. The last storm motion set by Warngen or the distance speed tool.
2. The average storm motion calculated by SCIT. (Same as the default storm motion for the regular 4-bit SRM)
3. Operator motion as set in the Radar Storm Motion Vector graphical user interface.

The decision on which of these three methods are used to set the storm motion is made by the user using the Radar Display Controls (See Fig. 4-7 on page 84.).

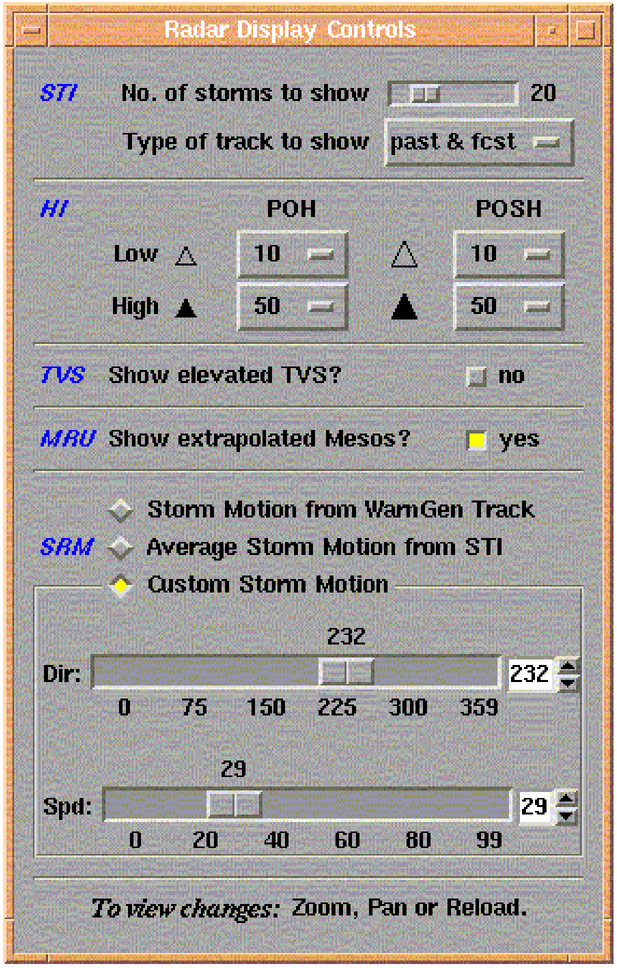


Figure 4-7. Operator input storm motion of 232° at 29 kts.

Product Uses

The 8-bit SRM product displays the highest resolution velocity data available from the radar out to 124 nm. When compared to the standard 4-bit SRM, it has greater detail spatially and in data magnitudes.

Product Description

8-bit SRM product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: 8-bit Storm Rel Vel - Map
- UNITS: kts (nautical miles per hour)
- DATE: Day of week, time, and date **in UTC**

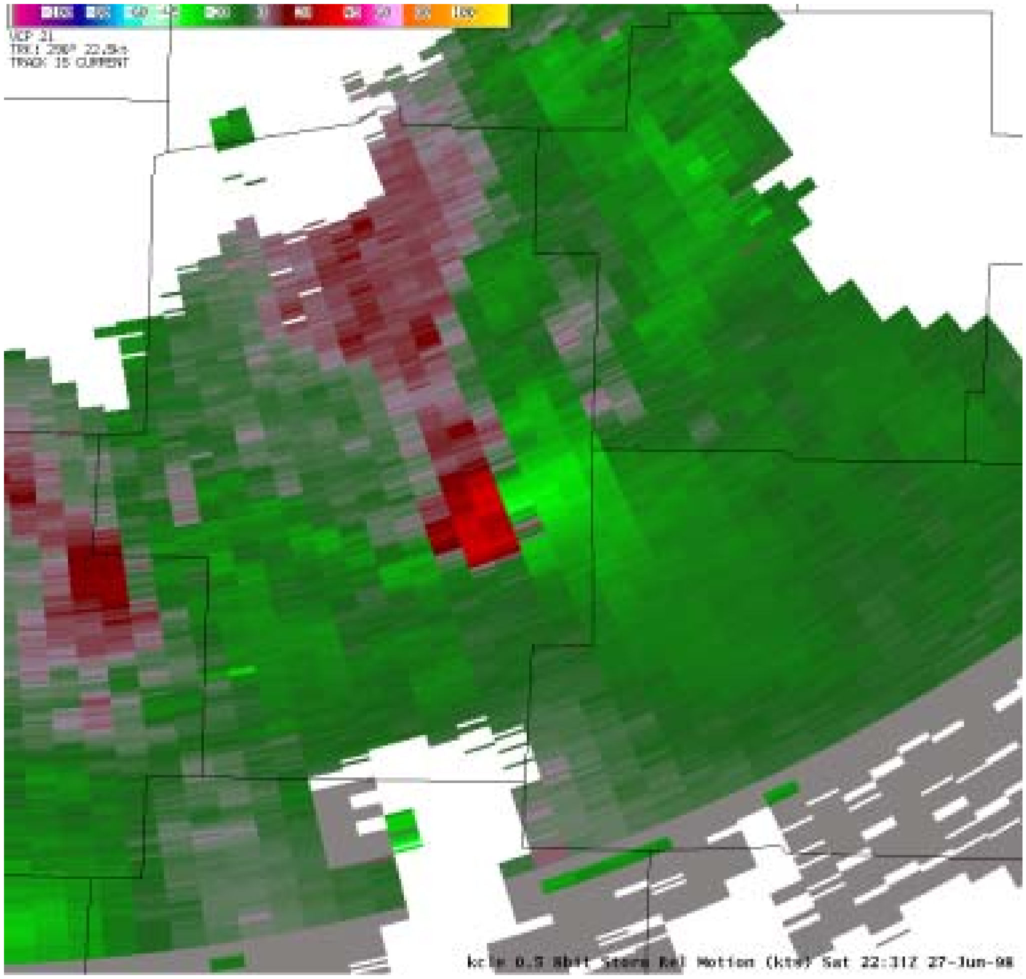


Figure 4-8. 8-bit Storm Relative Mean Radial Velocity Map product

8-bit SRM product annotations:

- VCP: VCP 11, 21, 31 or 32
- TRK: This is the storm motion which has been subtracted out (average of all identified cells). The direction in degrees and speed in kts.
- TRACK IS Current: This is the user supplied (either from Radar Display Controls or from WarnGen) storm motion which has been subtracted out. The direction in degrees and speed in kts.
- TRACK is Default: This is the SCIT Algorithm supplied storm motion. The average cell motion of all SCIT identified cells.

Additional 8-bit SRM product characteristics

- RANGE: 124 nm
- DATA LEVELS: 256
  - •• Defaults to (usually purple or white) for range folded data.)

8 Bit SRM Limitations

1. The 8-bit Base Velocity products used by AWIPS to produce the 8-bit SRM are large and **can produce narrowband loadshedding** unless a LAN-to-LAN connection is used.
2. Cannot do image pairing with reflectivity products and maintain resolution on the AWIPS HP workstations (LINUX workstations are OK with the use of procedures).
3. Suitable color tables need to be developed.
4. RPS list size restrictions may limit availability of needed 8-bit Base Velocity products to produce 8-bit SRM.
5. Care must be taken to ensure a representative storm motion is being produced by the default motion setting chosen.

8-bit SRM Strengths/ Applications

1. **High detail both spatially and in data magnitude** can provide improved detection of TVS's, Mesocyclones, Microbursts Boundaries
2. Same data levels and color scales can be used for both Clear Air Mode and Precipitation Mode VCPs.
3. High Storm Relative Velocities (up to 248 kts) are displayable and viewable on cursor readout sampling.

Storm Relative Mean Radial Velocity Region (SRR)

SRR Overview

The SRR is very similar to the SRM product only it is considered a "window" product. The SRR is generated for a small (approximately 38nm radial length) window of the radar coverage area centered on a user defined point (usually a storm of interest).

The motion subtracted from the product defaults to the storm closest to the product center. If no storm is within the product window, then the storm motion subtracted defaults to the average of all storms. If no storms are identified then the default is the default storm speed/direction set at the RPG HCI.

Just as with the SRM, the user can choose to override the algorithm generated motion and supply an operator defined motion if the default motion is in question.

The SRR has twice the resolution of the 4-bit SRM (.27 nm instead of .54 nm). Similar to the SRM, the SRR displays the maximum of every two 0.13 nm range bins.

SRR Product Parameters

The SRR product legend description:

- RPG ID: kxxx
- ELEVATION ANGLE: in degrees (any one in current VCP)
- PRODUCT NAME: Storm Rel Vel - Region
- UNITS: kts (nautical miles per hour)

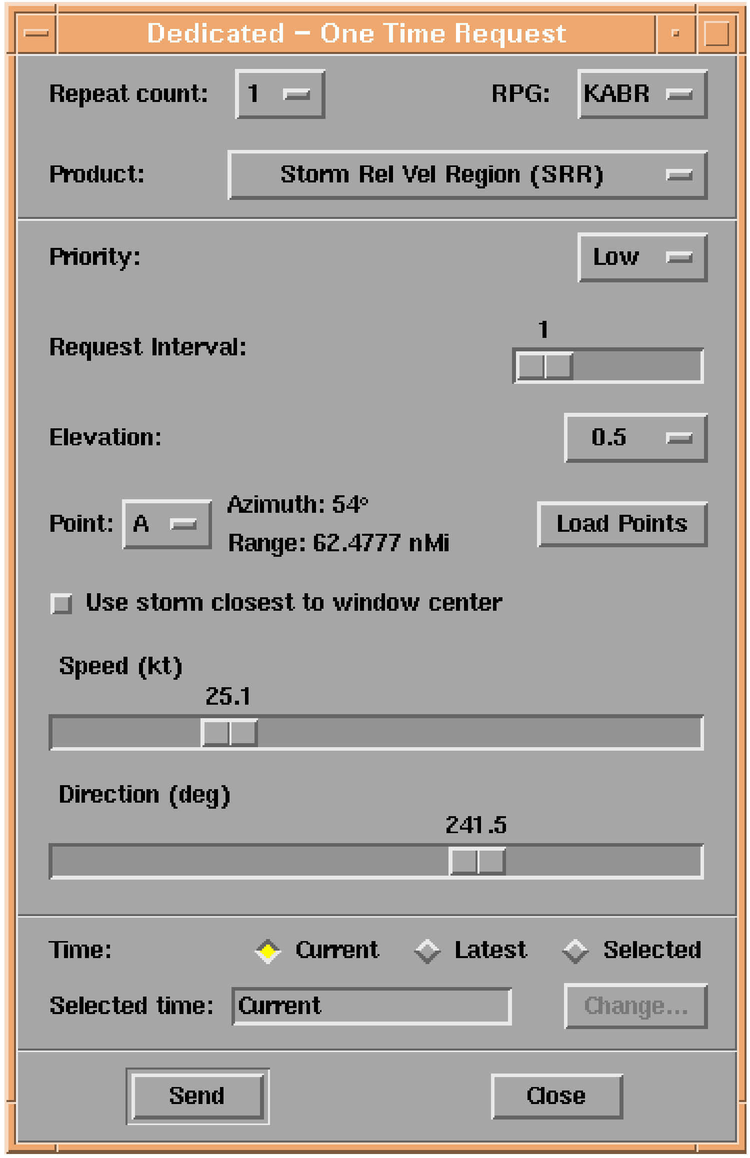


Figure 4-9. SRR product request screen.

- DATE: Day of week, time and date **in UTC**

SRR product annotations:

- VCP: VCP 11, 21, 31, or 32
- ALG: This is the default storm motion (motion of cell nearest product center)
- USR: This is the user supplied storm motion
- MN: This is the strongest inbound (negative) velocity detected in the window. The location

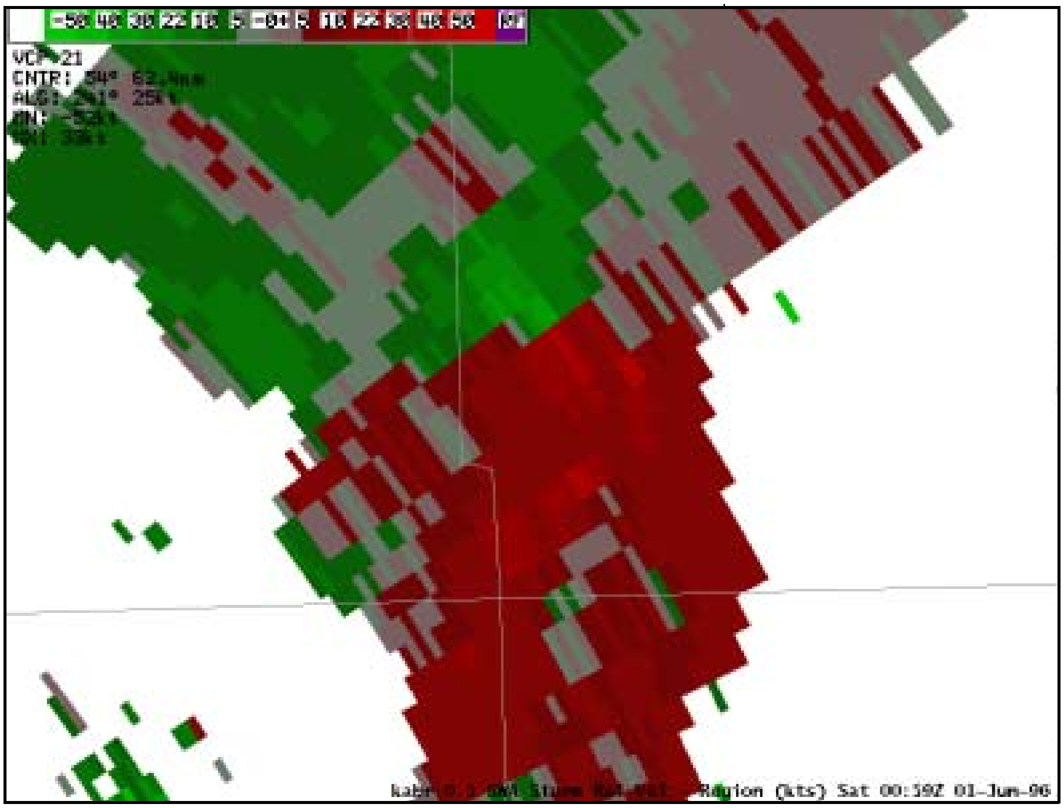


Figure 4-10. Storm Relative Mean Radial Velocity Region (SRR) product.

of this value is unknown, and this is a Storm Relative value.

- MX: This is the strongest outbound (positive) velocity detected in the window. The location of this value is unknown, and this a Storm Relative value.

Additional SRR product characteristics

- COVERAGE: approximately 38 nm radial length
- RESOLUTION: 0.27 nm
- CNTR - location of AZRAN selected (product center point)

RPS List

The SRR is NOT recommended for the RPS list. Since the product coverage is a small area, the storm of interest will likely move out of the window in a few volume scans. It is therefore better to get this product via a one-time request (using repeat count if desired for a few volume scans) or as an alert-paired product.

SRR Limitations

1. Storm relative flow will be inaccurate if storm motion used isn't representative of storm being investigated.
2. Difficult to determine ground-relative winds. Use Base Velocity products to determine ground-relative winds.
3. Limited viewing area.
4. Data levels are fixed.

SRR Strengths/ Applications

1. ***Better resolution and less chance for storm relative error than on the 4-bit SRM product***. The resolution of the SRR is .27 nm and uses only one storm motion as default, versus .54 nm resolution and the average of all storms with SRM.
2. Aids in displaying: shear and rotation in storms, and storm top divergence.
3. Operator may input storm motion at the AWIPS workstation.
4. Displayed max inbound/outbound velocities are valid within window.
5. Useful as an alert-paired product with Meso/TVS alerts.

Velocity Cross Section (VCS)

VCS Overview

The Velocity Cross Section is a cross section of the Base Velocity data. This product is produced in a similar manner as the Reflectivity Cross Section (RCS). ***Interpolation*** is used to fill data gaps. Although the horizontal resolution of the product is 0.54nm, the VCS uses the maximum value of every four 0.13nm range bins. Therefore, values displayed on the VCS may appear higher than on the 0.54nm Base Velocity products.

As with RCS, the two points picked must be within 124 nm of the RDA and no more than 124 nm apart.

Since radial base velocity data is used to produce the VCS, it is strongly suggested that the VCS be generated using two points either***:***

- ***along a radial*** to see convergent/divergent signatures and/or updraft/downdraft interface
- ***over a short distance perpendicular to the radial*** to see rotation.

Useful product, but not recommended for RPS list - Use this as a supplemental product, particularly in a research mode.

VCS Adaptable Parameters

If the user changes the velocity data levels for the Base Velocity products ***at the RPG HCI***, this will also change the data levels for the VCS.

VCS Product Characteristics

The Velocity Cross Section has the following characteristics:

- RESOLUTION: 0.54 nm horizontal res X 0.27 nm vertical res.
- COVERAGE: 124nm X 70,000 ft
- DATA LEVELS: 8 or 16 data levels
- Height on Z axis in 10,000 ft intervals.
- Range on x/y axis depends upon length of cross section (the endpoints are in km).
- Left side of product is western most point chosen (ENDPT1), unless along the same longi-

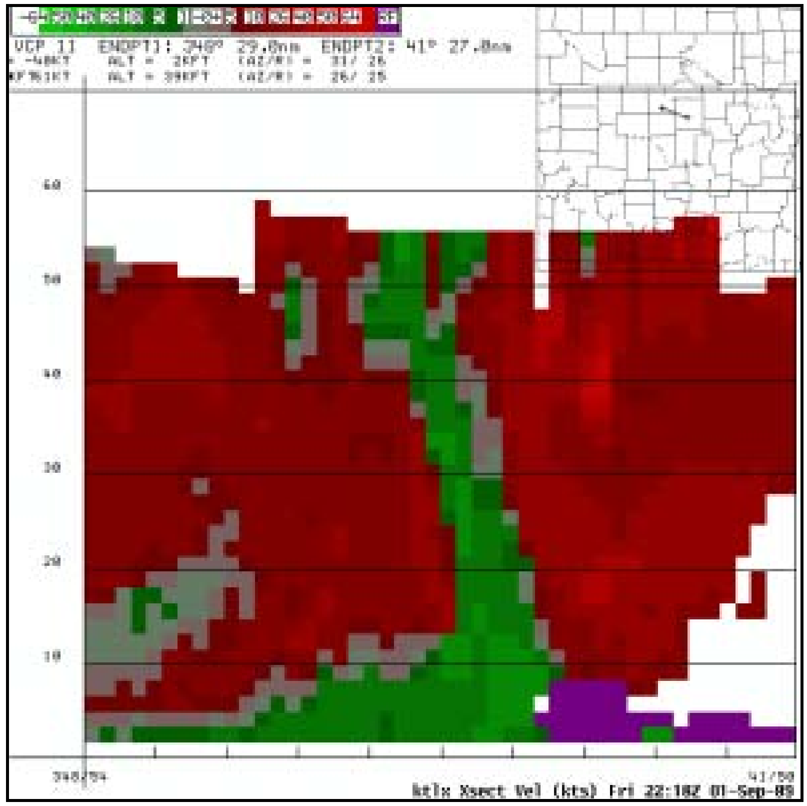


Figure 4-11. Velocity Cross Section (VCS) product. Note geographic location in upper right corner.

tude, then the northern point will be on the left side (ENDPT2).

VCS Product Parameters

See Fig. 4-11 for an example of the VCS Product

VCS product legend description

- RPG ID: kxxx
- PRODUCT NAME: Xsect Vel
- UNITS: kts
- DATE: Day of week, time, and date in UTC

VCS product annotations

- VCP: 11, 21, 31, or 32
- ENDPT 1: AZRAN of the western-most point (nm)
- ENDPT 2: AZRAN of the eastern-most point (nm)

- MIN (inbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)
- MAX (outbound) velocity, ALTitude (ARL in kft), AZ/R (AZRAN in degrees and nm)

VCS Limitations

1. ***Doppler velocities are relative to the RDA.*** As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. This increases the importance of baseline map in the upper right of the cross section.
2. ***Height exaggerated versus range*** (70,000 ft vs. up to 124 nm range). This is the same limitation observed in the RCS product. Features are not to scale, and appear thinner and taller than they actually are.
3. ***Interpolation may enlarge or miss features.*** Just as with the RCS product, gaps in the VCP will result in interpolations which may smooth out or enlarge a particular feature (especially in VCP 21).
4. ***Storm Relative cross section is <u>NOT</u> available. This may make it difficult to interpret signatures in especially fast moving storms.***
5. ***Storm top divergence estimates are limited due to radar viewing angle and data thresholds.*** Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the the storm summit.

* Remember, a VCS perpendicular to the radial can be used to see rotation, while a VCS along a radial can be used to see convergence/divergence. However, the ability to see features with the cross section products is highly dependent upon placement of the cross section. A 4-panel

velocity or SRM (or use all of the tilts) will probably get better results.

VCS Strengths/ Applications

1. Aid in determining storm structure features such as:
   - Inferring location of updrafts/downdrafts
   - Strength of storm top divergence
   - Depth of mesocyclones

2. Has proven very valuable for kinematic insights in a research setting.

Interim Summary

Storm Relative Mean Radial Velocity Map

1. Storm motion subtracted from Base Velocity data at the RPG.
2. Storm motion defaults to average motion of all storms from Storm Track algorithm, but operator may input motion.
3. Aid in determining shear regions and storm top divergence which may be obscured by storm motion.
4. Especially useful with faster moving storms.

8-bit SRM

1. Generated by AWIPS using the 8-bit Base Velocity at AWIPS.
2. The user can set the storm motion to either the last motion used by WarnGen, the average motion of all storms from Storm Track algorithm, or that directly input by the operator.
3. Provides higher spatial resolution (0.13 nm vs. 0.54 nm) and greater number of data levels (256 vs. 16) than the SRM product.

Storm Relative Mean Radial Velocity Region

1. Storm motion subtracted from Base Velocity data for a small geographical area.
2. Storm motion defaults to identified storm within a small window; resolution is .27 nm.
3. Useful as an alert-paired product.

Velocity Cross Section

1. Vertical cross section of the Base Velocity data.
2. Should be generated either along a radial to see convergent or divergent signatures, or over short distances perpendicular to a radial to see rotation.
3. Aid in inferring updraft/downdraft interface locations, storm top divergence and the depth of mesocyclones.

Velocity Azimuth Display (VAD)

VAD Overview

Although the VAD product is not a commonly used product, the VAD winds are output to two important places -- the VAD Wind Profile (VWP) Product and the Environmental Winds Table. Therefore, an understanding of the VAD Algorithm and VAD product is important.

You have used the Base Velocity products and attempted to infer wind speed and direction at a particular height (range) by using the zero isodop. The VAD algorithm attempts to do this at several heights. The VAD Product is a scattering of data points used to compute the wind speed and direction for a given height. Although only radial velocity (inbound or outbound) is measured at a given point, the radial velocities 360 degrees around the radar at a given height (range) can produce an estimate of the average wind speed, and actual wind direction (i.e., the azimuth of the strongest inbound wind approximates the direction the wind is coming from).

Algorithm Methodology

Slant Range

1. The VAD winds are computed using a single elevation angle at a constant ***slant range***. For each altitude requested on the VAD Wind Profile, the VAD Algorithm selects the elevation angle that is closest to intersecting that altitude at the ***VAD range*** (adaptable parameter with a default of 30 km or 16.2 nm). The actual slant range will change dependent upon the altitude for which the VAD wind is being calculated (See Fig. 4-12 on page 97.).

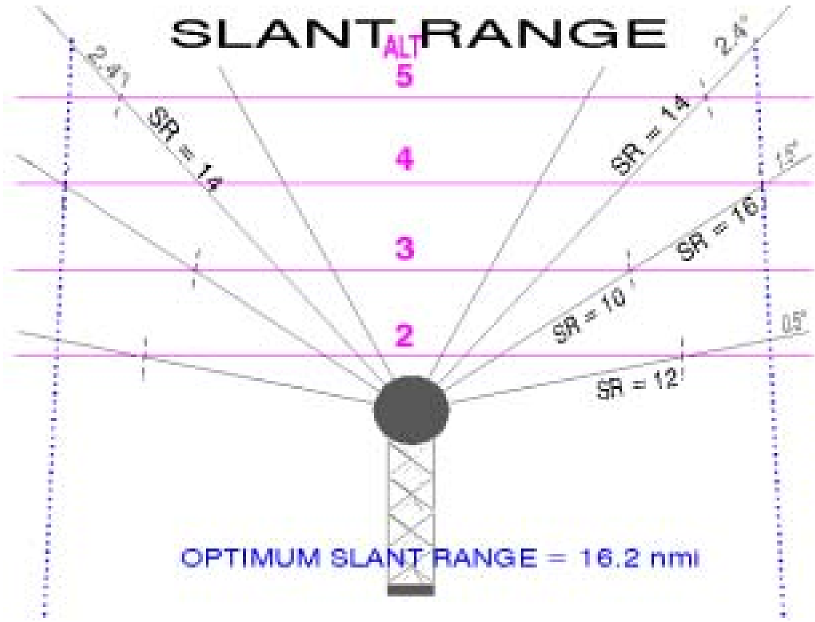


Figure 4-12. Slant Range

Velocity Data Plotted

2. ***A 0.13 nm resolution base velocity data point is plotted on a graph at each azimuth.*** The x-axis on the graph is azimuth (0°/360° for N, 180° for S of the RDA), and the z-axis is velocity (positive outbound velocities at the top and negative inbound velocities at the bottom).

Sine Wave Fit to the Data

3. If there are ***25 data points*** plotted on the graph, the algorithm then computes a ***sine wave*** to fit to the data (using least squares fit method). The VAD wind is computed from this sine wave. The amplitude of the sine wave is the estimated wind speed. The strongest inbound portion of the sine wave (closest to the bottom of the graph) becomes the estimated wind direction.

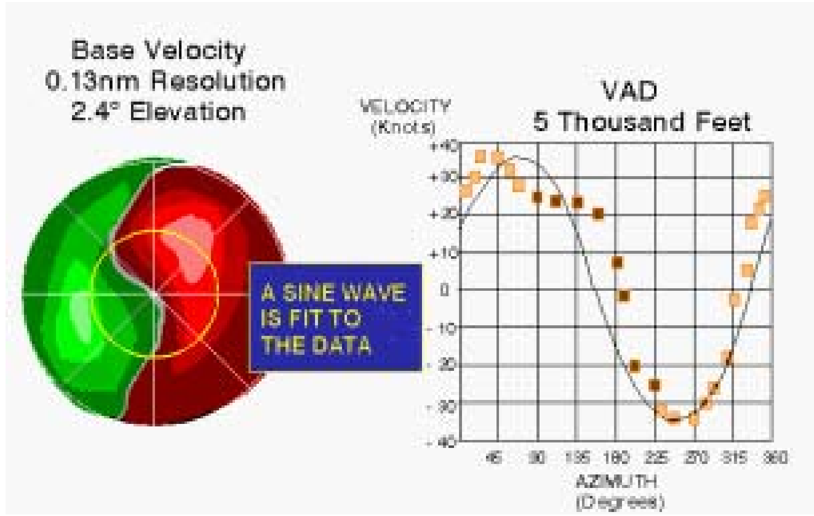


Figure 4-13. VAD data fit.

Symmetry and RMS error

4. Two additional values are calculated -- ***Symmetry and RMS error. Symmetry*** is the difference in knots between the zero velocity line on the VAD coordinate system and the median line of the sine wave curve. If the symmetry is negative (median line below the zero line) the inbound winds are stronger than the outbound indicating convergent flow at the radar site. Positive symmetry indicates diverging wind. ***RMS error*** (Root Mean Square error) is a calculation of the variation of the winds from the plotted sine wave. ***RMS error can be used as an indicator of the reliability of the wind estimate.***

If the symmetry exceeds 13.6 kts, or the RMS error exceeds 9.7 kts (ROC adaptable parameters), the winds can be determined by the operator using the plotted sine wave, but will not be output to the VAD Wind Profile (VWP) product.

VAD Altitudes

The VAD is available only for heights requested on VAD Wind Profile (VWP). These heights are determined by the user at the VAD and RCM Height Selection screen ***at the RPG HCI*** (URC adaptable). See Figure 4-14.

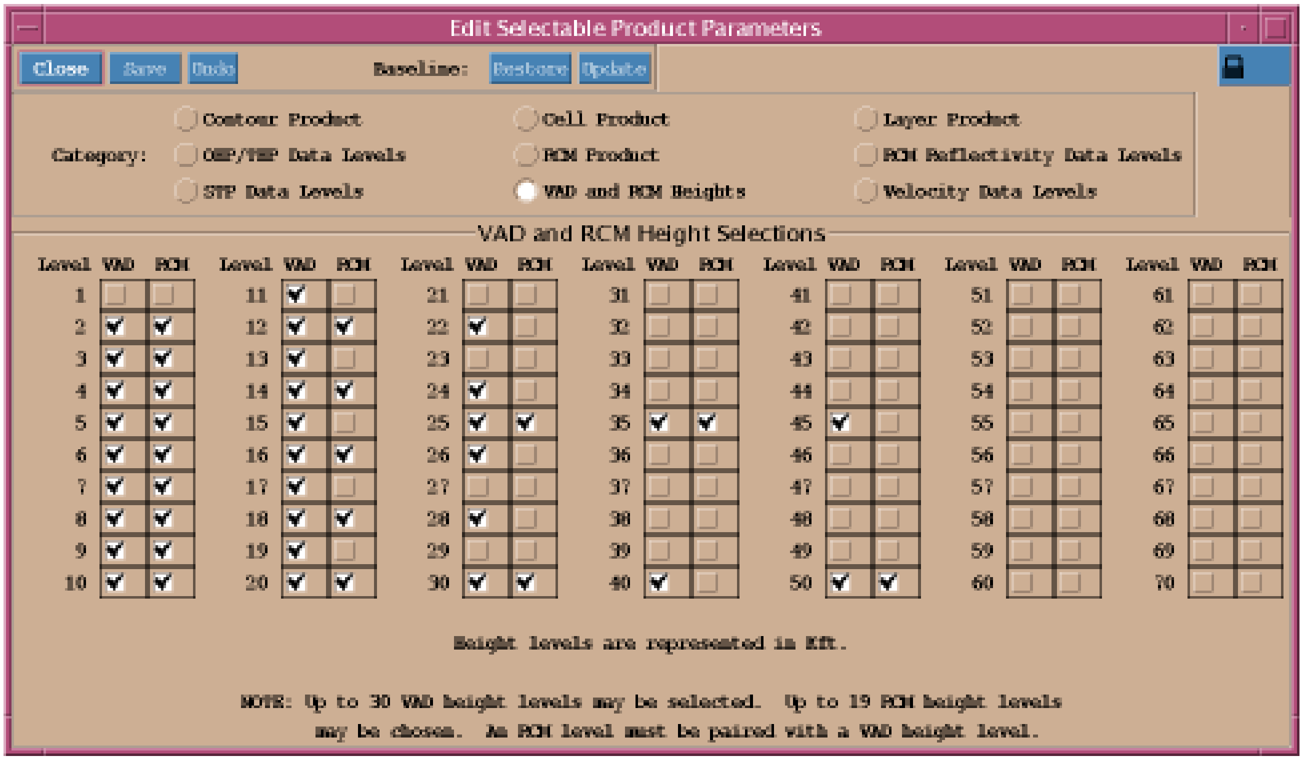


Figure 4-14. VAD Height Selection screen at the RPG HCI.

VAD Adaptable Parameters

There are three VAD adaptable parameters of importance: range, beginning azimuth and ending azimuth. They are edited at ***the RPG HCI***. See Figure 4-15.

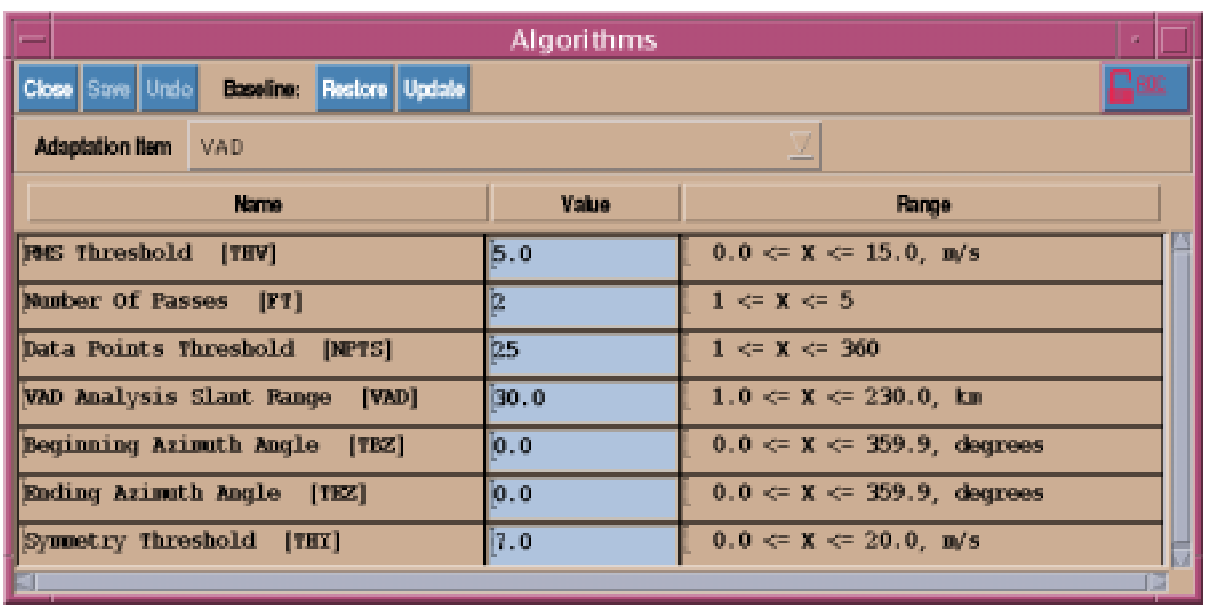


Figure 4-15. VAD Adaptable Parameters edit screen at the RPG HCI.

Output to the Environmental Winds Table

VAD winds are also output to the Environmental Winds Table used in the Velocity Dealiasing Algorithm. If the VAD winds are bad, the RPG HCI operator can turn off Auto Update, and manually input winds from a raob or profiler. See Figure 4-16.

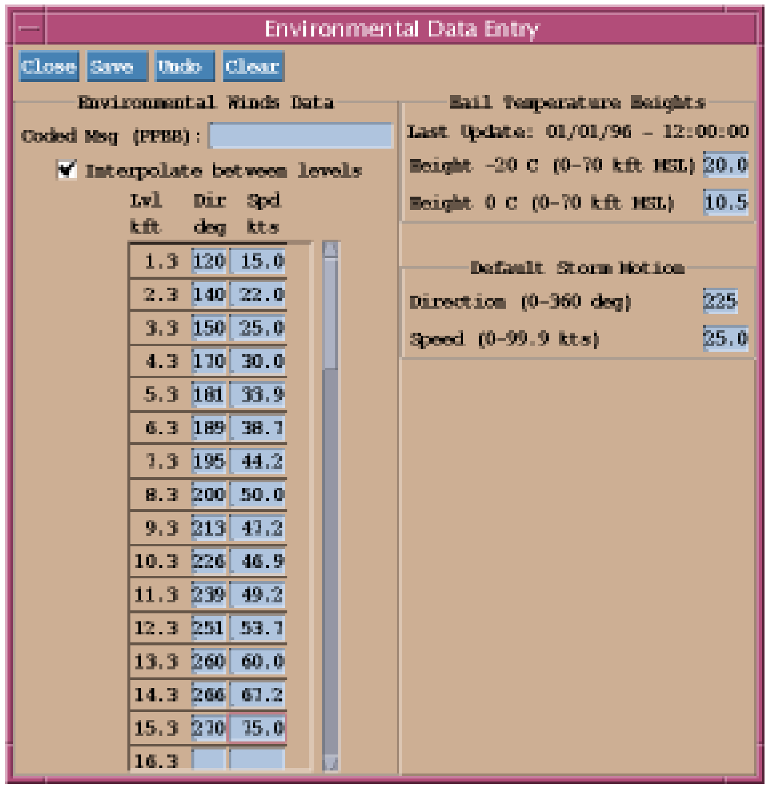


Figure 4-16. Environmental Winds Edit screen at the RPG HCI.

The VAD can be put on the RPS list or is available as a one-time request. The parameter that must be selected is the height in kft. See Figure 4-17.

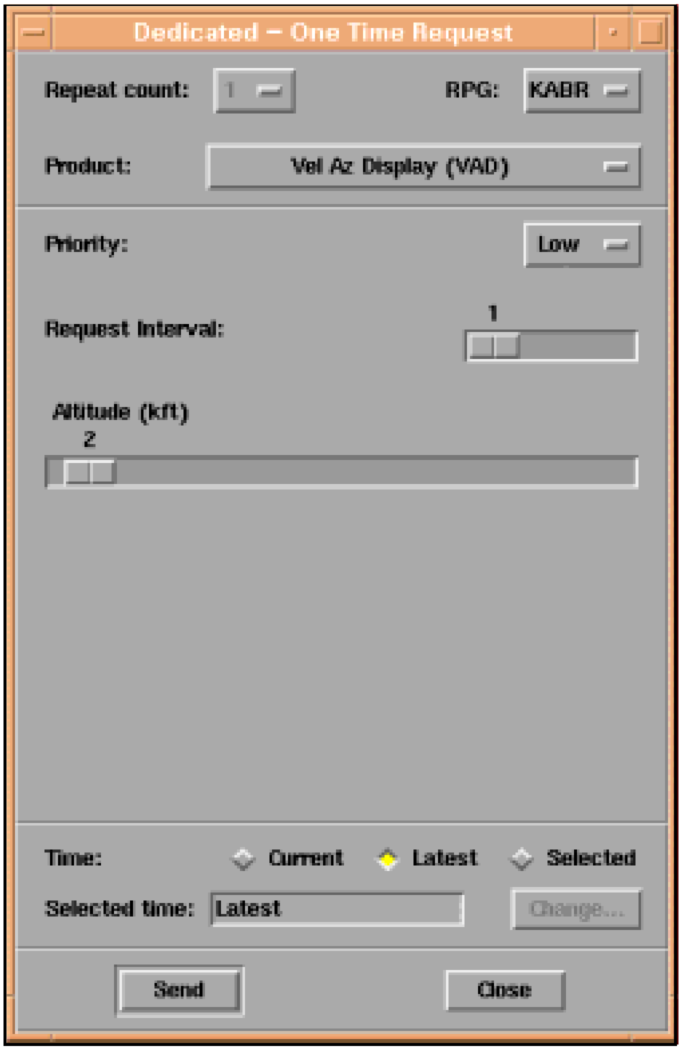


Figure 4-17. VAD product request screen.

VAD Product Parameters

See Figure 4-18 for an example of the VAD product

VAD product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Velocity Azimuth Disp
- UNITS: dBZ
- DATE: Day of week, time, and date in UTC

VAD Product Annotations

- VCP: 11, 21, 31 or 32

- ALT: Height in kft
- ELEV: Elevation angle that intersects selected height at the VAD range
- RNG: VAD Range
- WND: Wind direction and speed
- RMS: Root Mean Square error

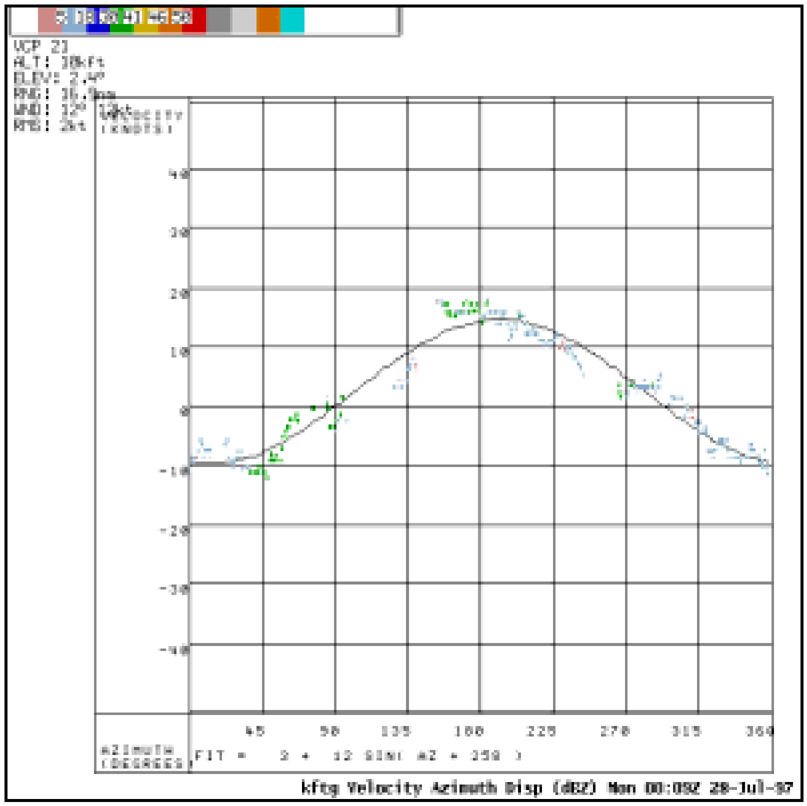


Figure 4-18. Velocity Azimuth Display (VAD) product.

VAD Limitations

1. ***Needs sufficient data points*** - Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. ***May be unreliable in disturbed environments*** - The algorithm assumes horizontal uniformity of the wind field. If there is a front or boundary near the RDA, the data will often fail either RMS or symmetry thresholds.

3. ***Available for preestablished altitudes only*** - As designated at the RPG HCI for the VAD Wind Profile.

4. ***Large flocks of migrating birds may produce anomalous wind data.*** The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an “explosion of reflectivity returns in a “butterfly” pattern centered on the RDA just after sunset.

VAD Strengths/ Applications

1. ***VAD Winds are available in clear air or precipitation mode***. Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower.

2. ***The VAD algorithm does not require 360 degrees of data.*** The algorithm only requires 25 data points (a sample from 25 degrees of azimuth), and they don’t have to be contiguous. It is possible to only sample a certain sector to produce the VAD winds. For example you could decide to only sample the area between 135° and 225° to get an estimate of the winds ahead of the front. The “Beginning” and “Ending” azimuth is set at the RPG HCI (under URC Control).

3. ***Check missing or suspicious wind data on the VAD Wind Profile (VWP)*** - This is probably the primary reason many operators choose to look at the VAD Product. When you see “ND” plotted on the VAD Wind Profile, you can request the VAD at that altitude and see what happened: no sine wave could be plotted due to high RMS error (>9.7 kts), convergence or divergence in the wind flow produced a symmetry error exceeding limits (>13.6 kts), or too few data points (<25).

4. ***Update Environmental Winds Table. The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize dealiasing errors.***

5. ***VAD winds included on the Radar Coded Message (RCM).***

VAD Wind Profile (VWP)

VWP Overview

The VAD Wind Profile Product (VWP) is a vertical profile of VAD-derived winds at various levels. Winds are plotted on a grid with the X-axis as time and the Z-axis as height in thousands of feet. As many as 11 profiles (11 volume scans) are plotted with the most recent profile at the far right side of the grid (opposite of the Wind Profiler Network time-height profiles).

Product Characteristics

The VAD Wind Profile (VWP) Product has the following characteristics:

- **Altitudes:** A maximum of 30 altitudes can be displayed each volume scan. The displayed MSL altitudes are selected at the RPG HCI. There must be a minimum of 1000 feet between levels. The lowest level selected should be the first altitude above the radar level (i.e., if the radar is at 2212 feet, then the lowest altitude selected should be 3 thousand feet). Altitudes to 70,000 feet can be selected, but winds above 45,000 feet are uncommon.
- **Wind Barbs:** Winds are displayed in the standard convention with the shaft always being the same length:
    - Small open circle - < 4 kts
    - 1/2 barb - 4-7 kts
    - full barb - 8-12 kts

- •• flag triangle - 50 kts

- **Data Levels** - The data levels of the VWP represent the RMS error in kts of the VAD winds. Recall that the RMS error is a measure of how well the sampled data points fit the sine curve. The first data level represent RMS errors less than 4 kts, the second data level 4-7 kts, and the third data level 8-11 kts. Higher data levels will not be seen on the VWP since **"ND"** will be displayed if the RMS error exceeds 9.7 kts.

- **ND** - No Data will appear if:
  - •• there are fewer than 25 data points
  - •• RMS error greater than 9.7 kts, or
  - •• symmetry is greater than 13.6 kts

VWP Product Parameters

See Figure 4-19 for an example of the VWP product

VWP product legend description:

- RPG ID: kxxx
- PRODUCT NAME: VAD Wind Profile
- UNITS: RMS kts
- DATE: Day of week, time, and date in UTC

VWP product annotations

- VCP: 11, 21, 31 or 32

- HT(MX): Height of the maximum wind from the most recent volume scan.

- MXWND: Maximum wind direction and speed from the most recent volume scan.

VWP Adaptation Data

The VWP Adaptation Data can be displayed at the AWIPS Text Display Window (WSRVWPxxx). This can be used to determine the adaptable parameter

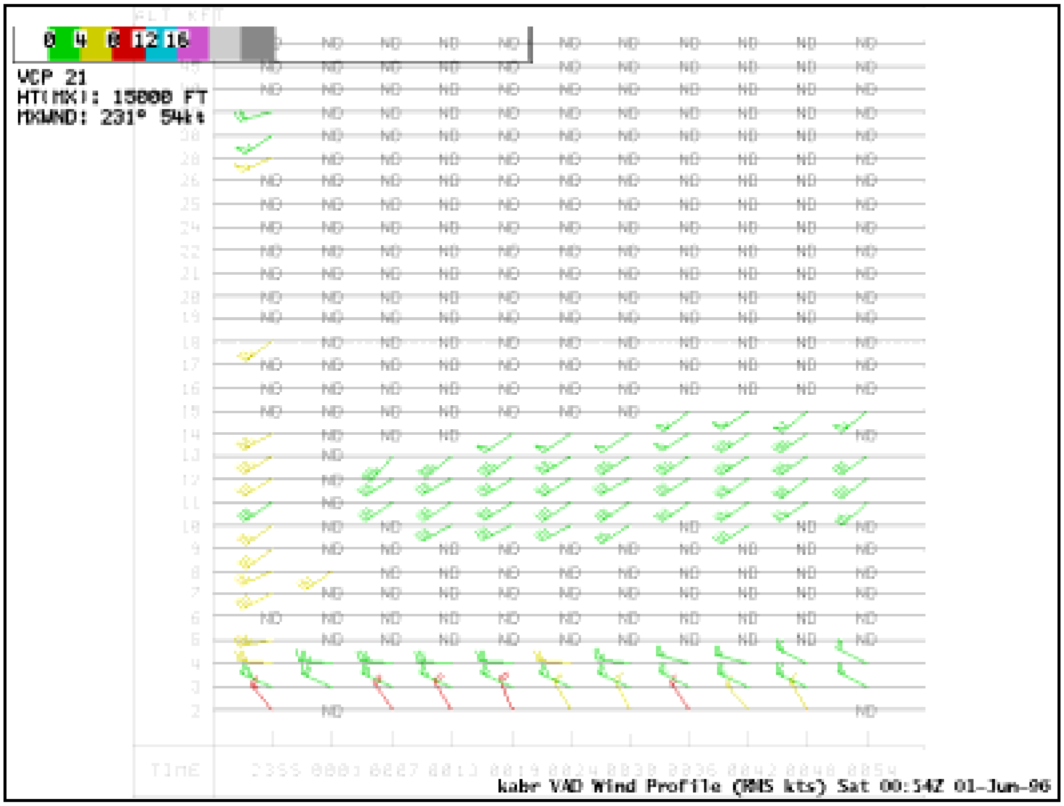


Figure 4-19. VAD Wind Profile (VWP) product.

settings used to generate the product. See Figure 4-20.

VWP Hodograph

The VWP can be also be displayed as a hodograph in an AWIPS Interactive Skew-T using the following method.

1. Load WFO Scale and editable points (no need to load radar data)
2. Move a point to the RDA
3. Open the Volume Browser and choose VWP as the source, sounding as the field, and the point corresponding to the one over the RDA
4. Select Load

Several fixes and improvements to the VWP Hodograph are planned for in AWIPS Build OB3 including an option to merge with data from RUC

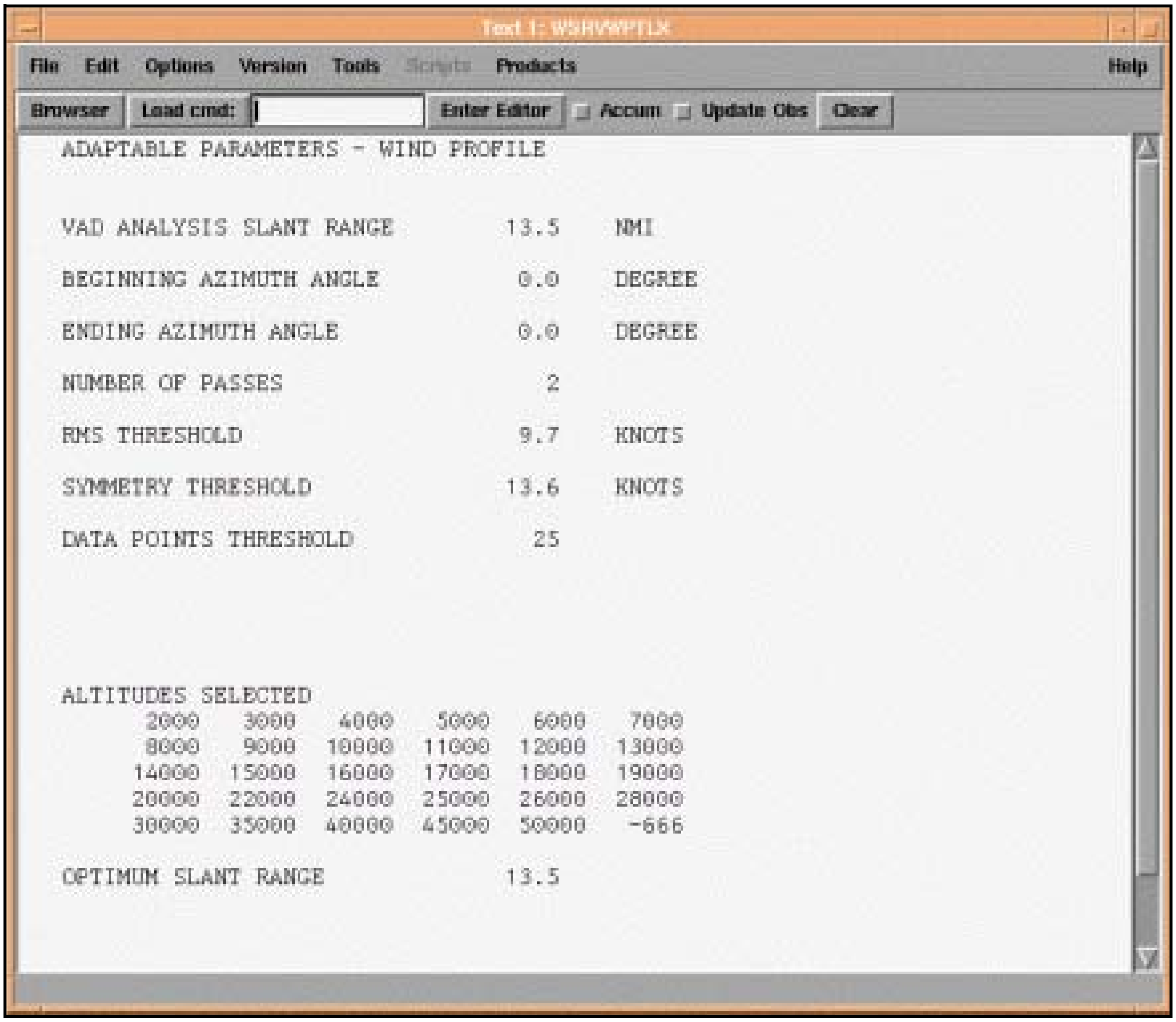


Figure 4-20. VWP adaptable parameters displayed at the AWIPS Text Display Window.

or LAPS. The attached graphic depicts some of the errors in the OB2 version.

VWP Limitations

1. ***Measurable returns needed -*** at least 25 data points are required on the individual VAD for data to be encoded at that altitude.
2. ***Winds are not encoded if RMS error or symmetry thresholds are exceeded.*** ND will be plotted if RMS exceeds 9.7 kts or symmetry exceeds 13.6 kts.
3. ***Generally only representative of winds within 20 nm of the RDA.***

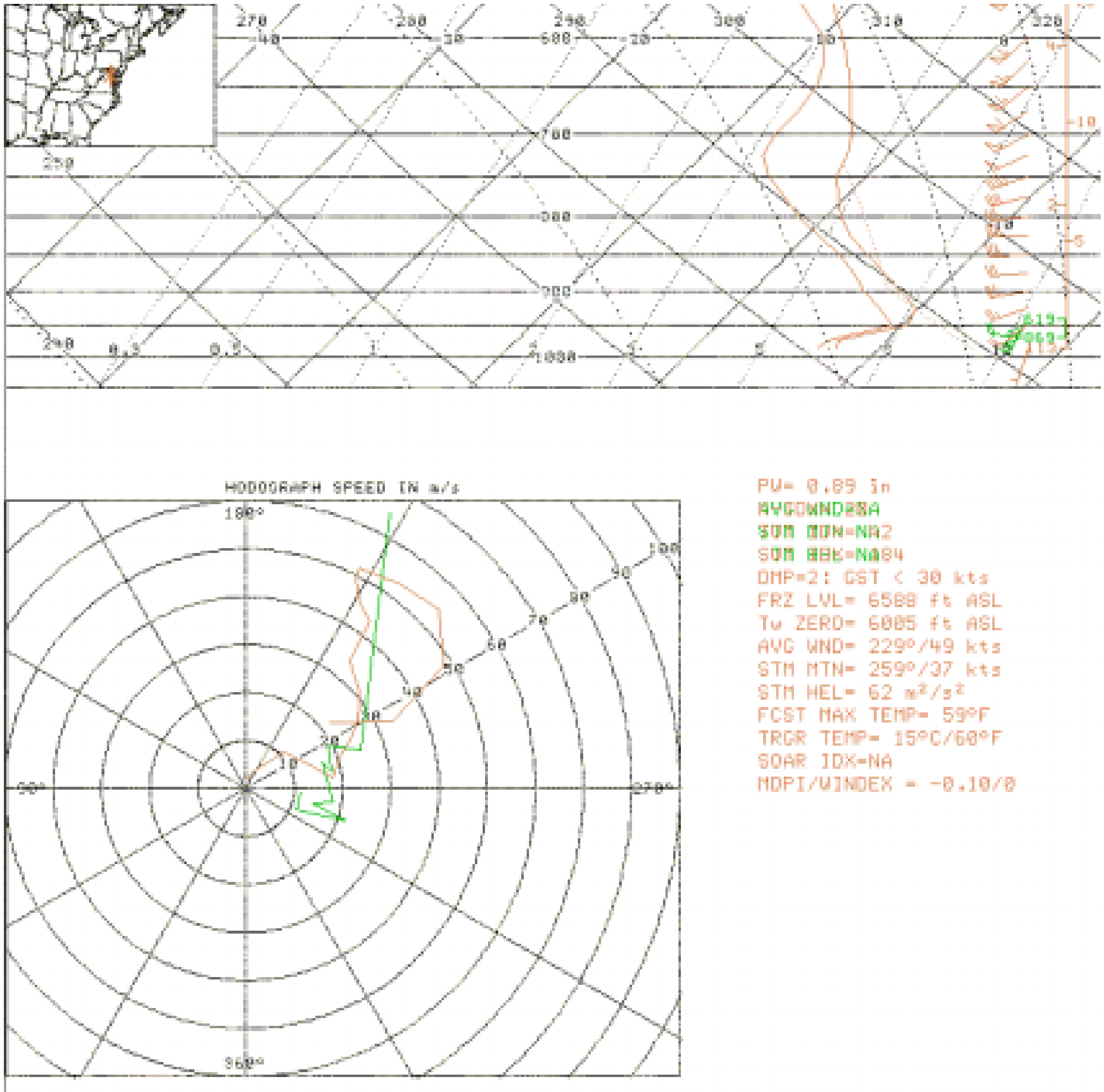


Figure 4-21. VWP hodograph (green) overlaid on Meso-Eta Hodograph (red).

4. ***Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.*** Use of the Filter or Blink Functions may help.

5. ***Birds can produce anomalous wind patterns.*** The usual scenario is an “explosion” of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

VWP Strengths/ Applications

1. The VAD Wind Profile (VWP) may be of assistance in many operations. ***Severe Weather*** operations may benefit as backing or veering of the winds with time display changes in the environment. ***Aviation*** operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. ***Hydrology*** and ***Forecasting*** may benefit from indications of the change in the depth of cold air with time, etc. Since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases.
2. ***The VWP can be used to create/adjust hodographs.***
3. ***Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity***.

Interim Summary

Velocity Azimuth Display (VAD)

1. A scattering of data points and a fitted sine wave curve are used to compute the winds for individual heights.
2. Product used primarily to check wind data that is "suspect" or missing on the VAD Wind Profile.

VAD Wind Profile (VWP)

1. A composite vertical profile of VAD-derived winds at various levels.
2. Excellent tool for meteorologists in weather forecasting, severe weather, hydrology, and aviation.
3. If fewer than 25 data points exist, or the symmetry or RMS thresholds are exceeded, the VAD Wind Profile will display "ND" (no data) for that height.

Mesocyclone (M)

Review Of Operator Identified Mesocyclone

Modified NSSL Mesocyclone Definition

- - Small scale rotation closely associated with a convective updraft that meets or exceeds established thresholds for:
  - --Persistence - Minimum of two volume scans
  - --Vertical extent- Shear extends at least 10,000 ft in the vertical
  - ***--Shear***
    - Distance between max inbound and max outbound ≤ 5 nm.
    - *Rotational velocity =* *velocity inbound + velocity outbound* *divided by* 2 (using mid-range values).

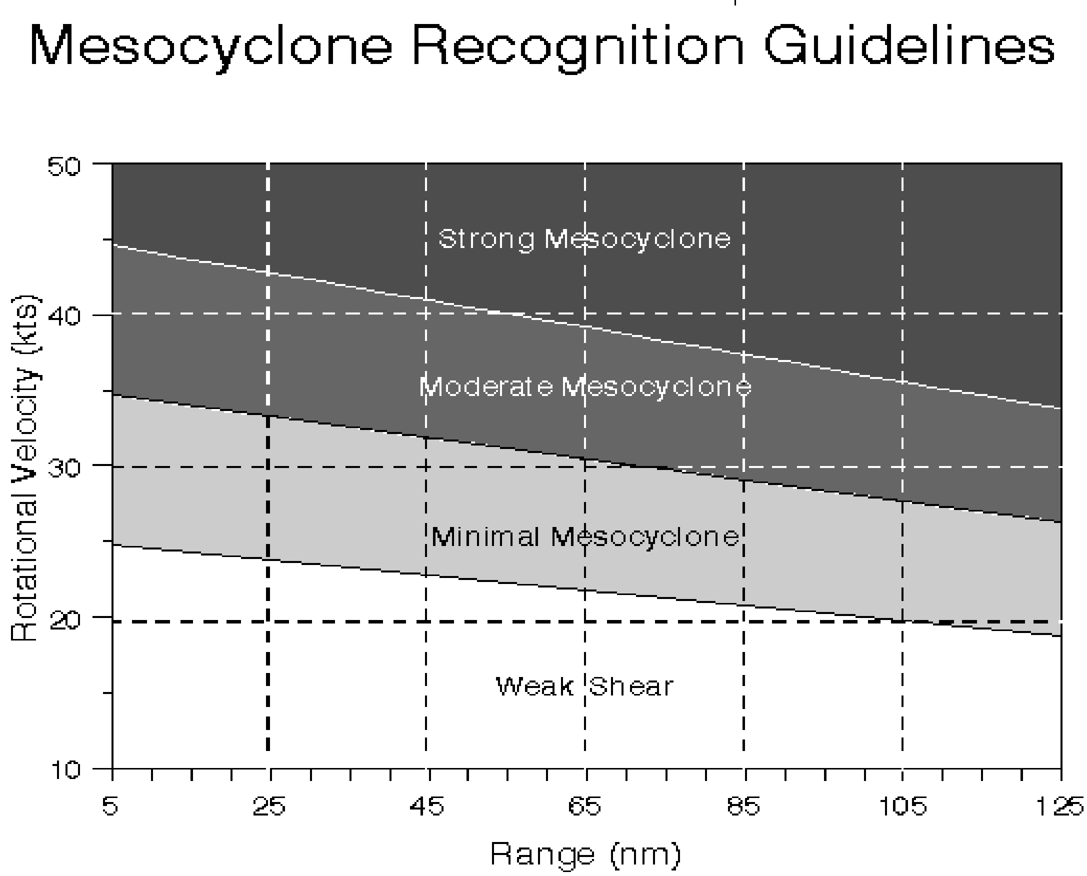


Figure 4-22. Assumes feature diameter of 3.5 nm.

Mesocyclone Algorithm

The Mesocyclone Algorithm does not identify mesocyclones the using the same guidelines as an operator.

Pattern Vectors

1. The Mesocyclone Algorithm first searches the dealiased 0.13 nm resolution Mean Radial Velocity data looking for azimuthally adjacent range bins that have a continual increase in Doppler velocity values. A series of these range bins is called a pattern vector.

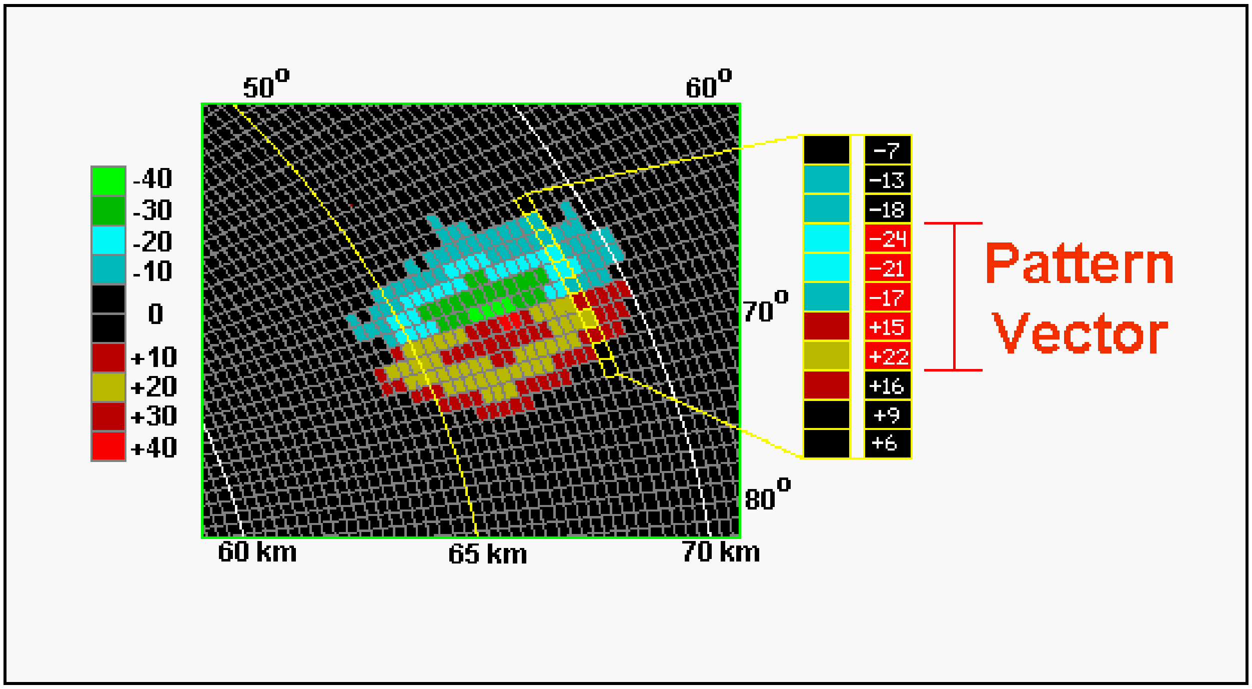


Figure 4-23. The Mesocyclone Algorithm pattern vectors.

Angular Momentum and Shear

2. Measurements are made of the change in velocity from the most negative to the most positive range bin, and the distance between these values. Calculations of ***angular momentum*** (distance X Δ velocity) and ***shear*** (Δ velocity / distance) can then be compared to minimum thresholds (adaptable parameters). If these minimum thresholds are not exceeded then the pattern vector is discarded from further processing.

Mesocyclones often evolve from high angular momentum and low shear in the developing stage, to low angular momentum and high shear in the mature stage. The algorithm allows for both high momentum-low shear features and low momentum-high shear features to be identified as mesocyclones.

2-D Features

3. Pattern vectors at each elevation angle are then consolidated according to their relative spatial proximity. If this group of pattern vectors exceeds a ***minimum number threshold*** (adaptable parameter - TPV) they are considered a ***2-D Feature.***

Symmetry

4. Each 2-D Feature is then tested for ***symmetry***. If the ratio of the 2-D Features ***radial length*** to its ***azimuthal length*** falls within certain range dependent thresholds, then that 2-D feature is classified as symmetrical. If the ratio falls outside those thresholds the feature is classified as not symmetrical.

Vertical Correlation

5. The 2-D features are correlated with features on elevation angles both above and below. The 2-D features are considered circular for this comparison. The diameter of the circle would be the larger of either radial length, or azimuthal diameter. If the center point of the smaller 2-D feature is vertically located within the area of the larger feature, then the features are considered ***vertically correlated*** (3-D Feature).

Three Classifications

6. If a 2-D feature cannot be vertically correlated, then the feature is classified as an ***<u>Uncorrelated Shear</u>***. If two or more 2-D features are vertically correlated, but less than two are classified as symmetrical, the 3-D Feature is classified as a **<u>3-D Shear</u>**. If two or more of the vertically correlated

features are symmetrical the 3-D feature is classified as a **Mesocyclone**.

Mesocyclone Graphic Product Description

The ***Mesocyclone Symbol*** is a yellow circle (the line width is 4 pixels) with the storm ID of the closest identified storm (from the Storm Tracking Algorithm) located just to the SE of the symbol.

The ***3-D Correlated Shear Symbol*** is also a yellow circle (the line width is only 1 pixel), but with no storm ID number.

Both the Mesocyclone and 3-D Shear Symbols are centered at the center point of the lowest 2-D feature. The size of the symbol corresponds to the size of the identified mesocyclone or 3-D shear, but symbol size is unchanged by magnification using AWIPS. This can be misleading! **Don't associate symbol size with the severity of the storm**.

Note that Uncorrelated Shears are not displayed on the graphic product.

Mesocyclone Product Parameters

See Figure 4-24 for an example of the Mesocyclone product.

Mesocyclone product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Mesocyclone
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

Mesocyclone product annotations

- Mesocyclone Attribute Table

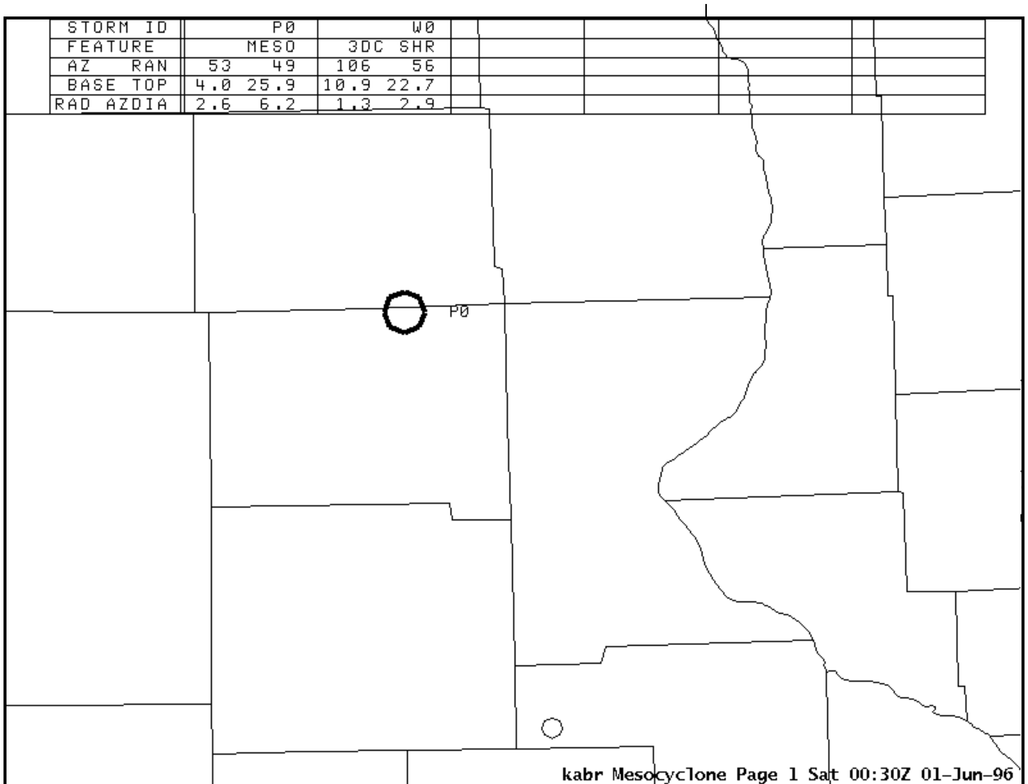


Figure 4-24. Mesocyclone (M) product

Additional Mesocyclone product characteristics

RANGE: 124 nm

Mesocyclone Attribute Table

The Mesocyclone Attribute (color coded yellow) Table is available if any Mesocyclones or 3-D Correlated Shears are detected. If there are Uncorrelated Shears, but no Mesocyclones or 3-D Correlated Shears, the area where the Attribute Table is displayed will be blank. If there are no Mesocyclones, 3-D Correlated Shears, or Uncorrelated Shears, then “**NO MESOS**” is displayed in the Attribute Table area. See Figure 4-25

STORM/ID		P0		W0
FEATURE		MESO		3DC SHR
AZ RAN	53	49	106	56
BASE TOP	4.0	25.9	10.9	22.7
RAD AZDIA	2.6	6.2	1.3	2.9

Figure 4-25. Mesocyclone Attribute Table which appears at the top of the MESO product.

The Mesocyclone Attribute table list:

- -**STORM ID** -- of the nearest storm centroid,
- -**FEATURE** -- MESO or 3DC SHR,
- -**AZ**imuth **RAN**ge -- azimuth in degrees and range in nm (to the center of the feature),
- -**BASE TOP** -- the Base and Top of the feature in kft (ARL) (does not give elevation angles to help the user quickly examine base products), and
- -**RAD AZDIA** --radial and azimuthal diameter.

Mesocyclone Alphanumeric Product Description

The Mesocyclone Alphanumeric Product is paired with the Mesocyclone Graphic, and available as a text product in AWIPS (WSRMESxxx). Since most of the information in the alphanumeric product is available on the product or in the Mesocyclone Attribute Table, the only significant operational use is as in indication of the setting for adaptable parameters such as the Total Pattern Vector.

- -**FEAT ID** -- An internal numbering system for the algorithm.
- -**STOR ID** -- This is the ID of the closest storm - not necessarily the storm with the mesocyclone.
- -**FEAT TYPE** -- MESO, 3-DC SHR, or UNC SHR
- -**BASE, TOP** -- base and top in kft (ARL)
- -**AZRAN** -- azimuth and range of feature
- -**HGT** -- height of strongest shear in kft (ARL)
- -**DIAMETER** -- radial length and azimuthal diameter

Mesocyclone Adaptable Parameters

At the end of the Mesocyclone Alphanumeric Product is a list of adaptable parameters. Changes to these parameters may come about from experience with the radar and low types of convection.

One parameter that is under URC control is Min. # Pattrn Vec. The Threshold Pattern Vector (TPV) defines the minimum number of pattern vectors in a 2-D Feature. Sites may change the value from 10 to lower values, but no lower than 6. By lowering TPV, the Mesocyclone Algorithm should detect smaller features such as those associated with low topped convection or mini-supercells. However, this change may generate more false alarms. If the change has a detrimental effect on the algorithm's performance, return the adaptable parameter to its original value of 10.

An example of an ROC adaptable parameter is **MAX HGT MESO** (currently set at 8 km or approximately 26 kft). Any 2D-Feature found above this height is discarded to eliminate transient shears. Since the 1.5° beam height at 110 nm is about 26,000 ft, no mesocyclones or 3D shears would be detected beyond 110 nm. See Figure 4-26.

The Mesocyclone Product is recommended for the RPS List whenever convection is expected.

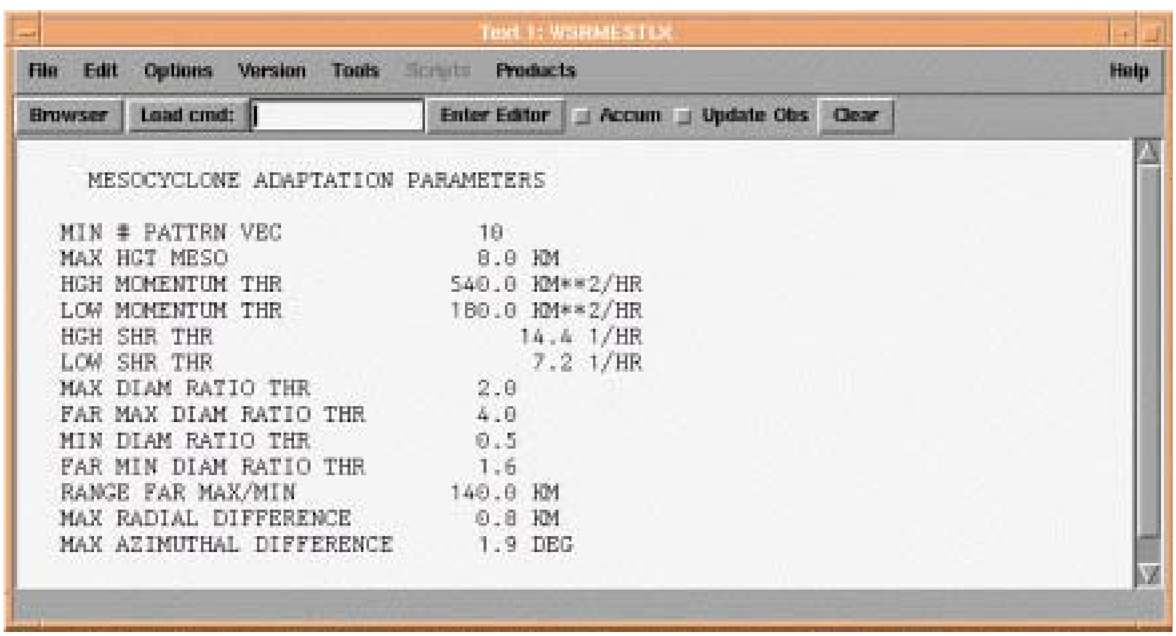


Figure 4-26. Mesocyclone adaptable parameters displayed at the AWIPS Text Display Window.

Mesocyclone Alerts

Since the Mesocyclone Product is usually on the RPS list, other products are often alert-paired with the Mesocyclone Alert. The Storm Relative Mean Radial Velocity Region Product (SRR) or the Severe Weather Analysis Velocity Product (SWV) are “window” products which are often used.

If the operator sets the alert category to be alerted for a mesocyclone, the “window” product sent with that alert is centered at the location of the mesocyclone. The alert categories of 3-D Shear or Uncorrelated Shear are not recommended. One reason is that the “window” product sent with the alert will be centered on the centroid of the closest identified storm. The product area may not include the feature producing the alert.

Mesocyclone Limitations

1. **Time continuity is not employed**. - The algorithm does not wait for 2 volume scans.
2. **Does not need 10,000 ft deep circulation. -** The algorithm only requires 2 vertically linked elevation angles.
3. **The algorithm only detects cyclonic rotations**.
4. **Identification is influenced by aspect ratio.**
5. **Don't know which elevation angle to examine shear.** - Attribute Table and Mesocyclone Alphanumeric Product only give height.
6. **Range thresholds may discard or improperly classify mesocyclones. No data within 10 km (5.4 nm) is processed by the mesocyclone algorithm. -** Search Base Products for evidence mesocyclones.
7. Improper dealiasing may generate false mesocyclones.
8. Algorithm default values adapted for classic supercells.

Mesocyclones Strengths/ Applications

1. **Identify mesocyclones -** The operator must examine reflectivity, velocity/SRM to verify existence of mesocyclones.
2. **A mid-level mesocyclone that lowers toward the surface may indicate a tornado is developing.**

Mesocyclone Rapid Update (MRU)

Overview

The Mesocyclone product is not available until the end of the volume scan even though potential circulations may have been detected midway through the volume scan. The Mesocyclone Rapid Update (MRU) product (new in RPG Build 4 and AWIPS Build OB2) provides Mesocyclone Algorithm results ***for each elevation angle during a volume scan***. The MRU information for any given elevation angle is based on the elevations that have been completed thus far in the current volume scan.

MRU Algorithm Process

The MRU uses output from both the Mesocyclone and Storm Cell Identification and Tracking (SCIT) Algorithms from the previous volume scan. For example, a MESO has been identified for a particular volume scan. The average motion of all SCIT storm cells from that volume scan is applied to the identified MESO in order to extrapolate the position of that MESO to the subsequent volume scan.

For each elevation angle of the current volume scan, MRU attempts to match newly identified features to features identified from the previous volume scan. The MRU product is then generated for each elevation angle of the current volume scan.

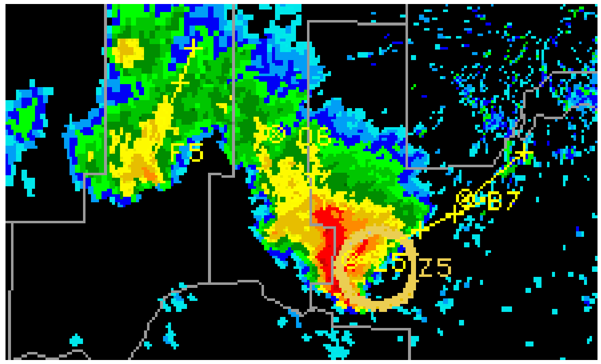


Figure 4-27. Legacy Mesocyclone Algorithm and SCIT results overlaid on Base Reflectivity.

Matching Features

Extrapolated (EXT) positions of features identified from the previous volume scan are determined using the average motion of all cells identified by the SCIT Algorithm. For the current volume scan, the extrapolated position of each previous feature is matched to the closest current feature within a search radius defined by the SCIT Algorithm (default 10 km).

If there is a match

If there is a match, the current feature initially inherits the attributes of the previous feature. These attributes include:

- Storm ID
- Strength Attributes:
  - Feature type (MESO, 3D SHR, or UNC SHR)
  - Maximum tangential shear
  - Radial and azimuthal diameter (DIAM RAD AZ) and height of the max shear (HGT)
- Position Attributes:
  - Base azimuth, range (AZRAN) and height
  - Top height

Increasing vs. Persistent

As the current and additional elevation angles are processed, the inherited attributes may change. If the max shear increases, or the feature type increases (e.g., 3D SHR to MESO), the feature status is **Increasing (INC)**. The max shear or feature type will then be updated to the current volume scan value and will be denoted with a **^** symbol in the MRU attribute table.

If the max shear or feature type do not increase, the feature status is **Persistent (PER)**.

If there isn't a match

At the beginning of each volume scan, all MESOs, 3D SHRs, and UNC SHRs from the previous volume scan Mesocyclone Algorithm are passed to the MRU. These features' status will be labelled **Extrapolated (EXT)** until there is a match (once matched, status will be PER or INC). The number of EXT features will typically be higher near the beginning of a volume scan, then decrease as additional elevations are processed and more matches are made. At the end of the volume scan, the EXT features are removed.

If a 3D feature is newly identified in the current volume scan, but cannot be matched to a feature in the previous volume scan, its status is **New (NEW)**.

Mesocyclone Rapid Update (MRU) Product

The Mesocyclone Rapid Update (MRU) product is a new elevation based product with RPG Build 4 and AWIPS Build OB2. The MRU can be displayed by selecting a particular elevation angle, or by selecting the "latest MRU" (Figure 4-28). The "latest MRU" option will result in a display that will automatically update as new elevation angles of the MRU arrive.

The MRU graphical product uses traditional MESO (thick circle) and 3D SHR (thin circle) symbols.

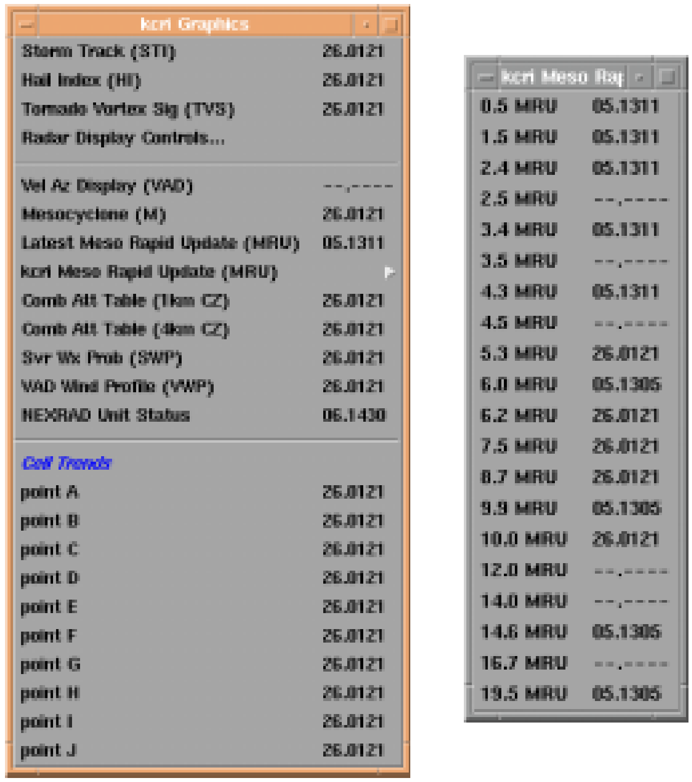


Figure 4-28. The menu structure to display the MRU. From the KXXX Graphics Menu, there are two options for MRU display, a particular elevation angle or the latest MRU. The latest MRU option will result in a display that will automatically update as new elevation angle MRUs arrive.

The size of the circle is proportional to the average of the radial and azimuthal feature diameters, just as with the legacy MESO product. If the feature status is INC, PER, or NEW, the circle outline will be solid. If the feature status is EXT, the circle outline will be dashed.

As with the legacy Mesocyclone product, the MRU graphical product can be displayed as an overlay to other products from the same volume scan. In Figure 4-29, the 0.5° MRU is overlaid with the 0.5° SRM. In this example the elevation angles match, but this is not a requirement. The MRU can be overlaid with products from different elevations, provided that the volume scan times match.

In Figure 4-29, several of the MESOs have the status EXT or extrapolated, which is depicted by the dashed circles. This is to be expected for the lower elevations of a new volume scan, as the MRU has not yet processed the elevations needed to match a MESO or 3D SHR to the previous volume scan.

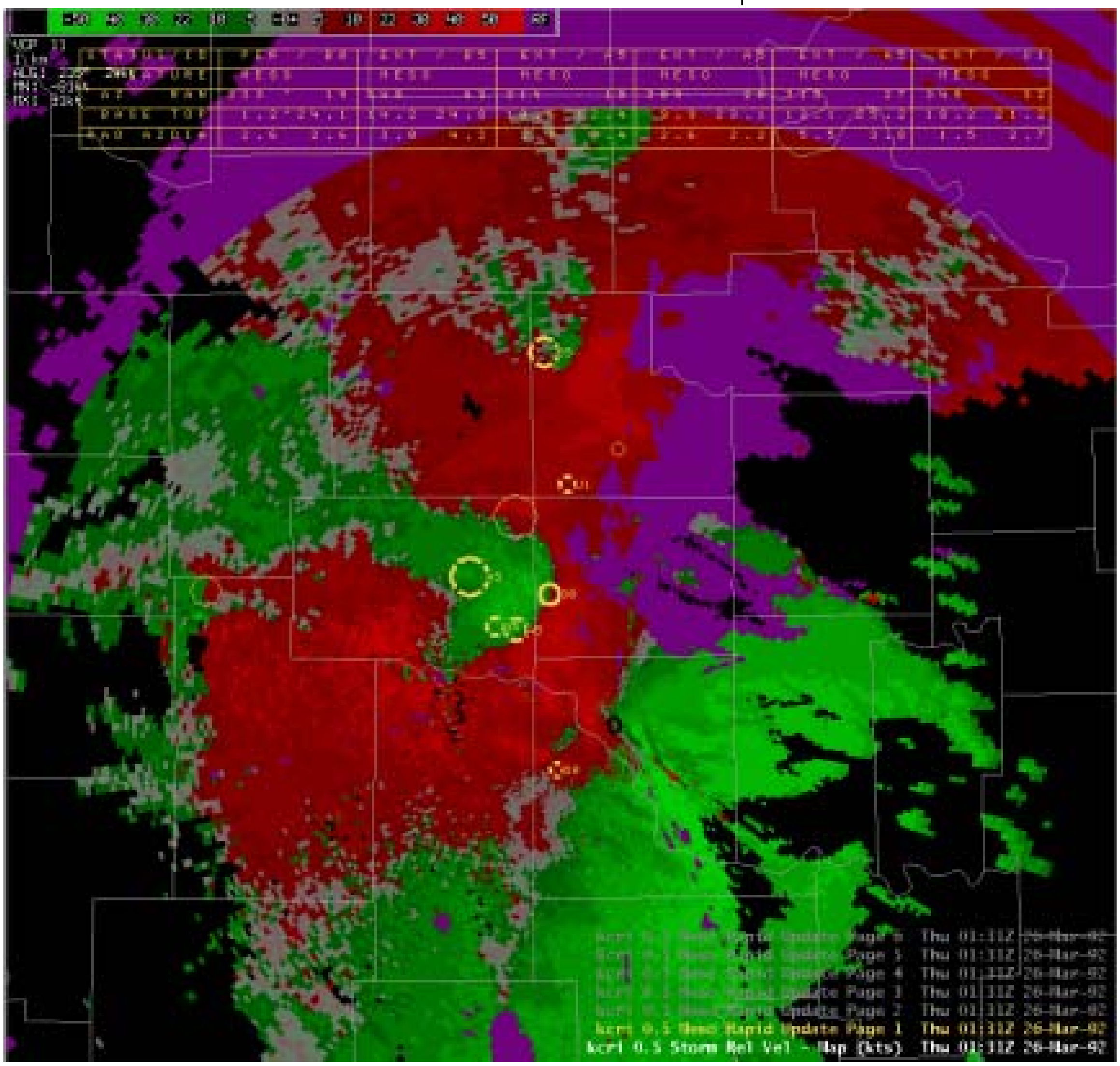


Figure 4-29. A 0.5° SRM with 0.5° MRU overlaid. Note that the status of the majority of the mesos is EXT for extrapolated. The matching to features from the previous volume scan will improve as additional elevations are processed.

As the MRU continues to process additional angles in the volume scan, more matches will be made. In Figure 4-30, the 6.0° MRU is overlaid

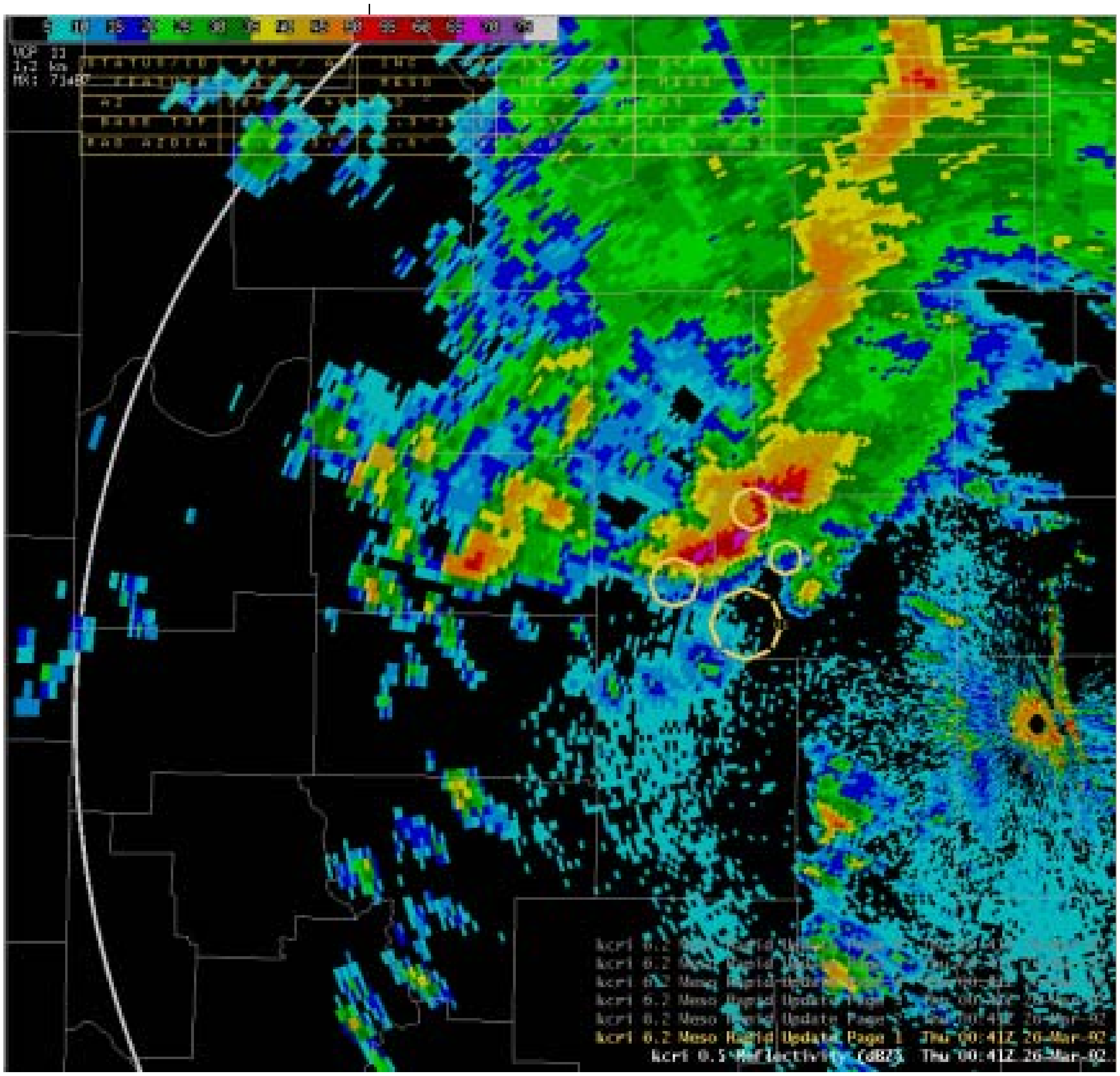


Figure 4-30. A 0.5° Base Reflectivity with 6.2° MRU overlaid. Note that of the four features, three are matched (INC or PER) with solid circles, while one remains unmatched (EXT) with a dashed circle.

with the 0.5° Base Reflectivity. Note that the elevation angles do not have to match, just the volume scan time.

MRU Graphic Attribute Table

Also similar to the legacy Mesocyclone product, the MRU has an associated graphical attribute table. This table has attribute information for each identified storm that has a MESO or 3D SHR.

The MRU Attribute Table in Table 4-1 provides examples of some of the four possible status types for an identified feature. This is the information from the Attribute Table in Figure 4-30.

Table 4-1: Example of MRU Graphic Attribute Table

STATUS/ID	PER / A0	INC / A0	INC / B0	EXT / U1
FEATURE	MESO	MESO ^	MESO ^	MESO
AZ RAN	307 46	303 ^ 39	291 ^ 51	289 40
BASE TOP	4.0 24.2	7.3 ^ 25.1	9.9 ^ 20.6	11.9 23.1
RAD AZDIA	6.2 3.6	2.6 ^ 5.4	5.0 ^ 6.7	8.9 8.2

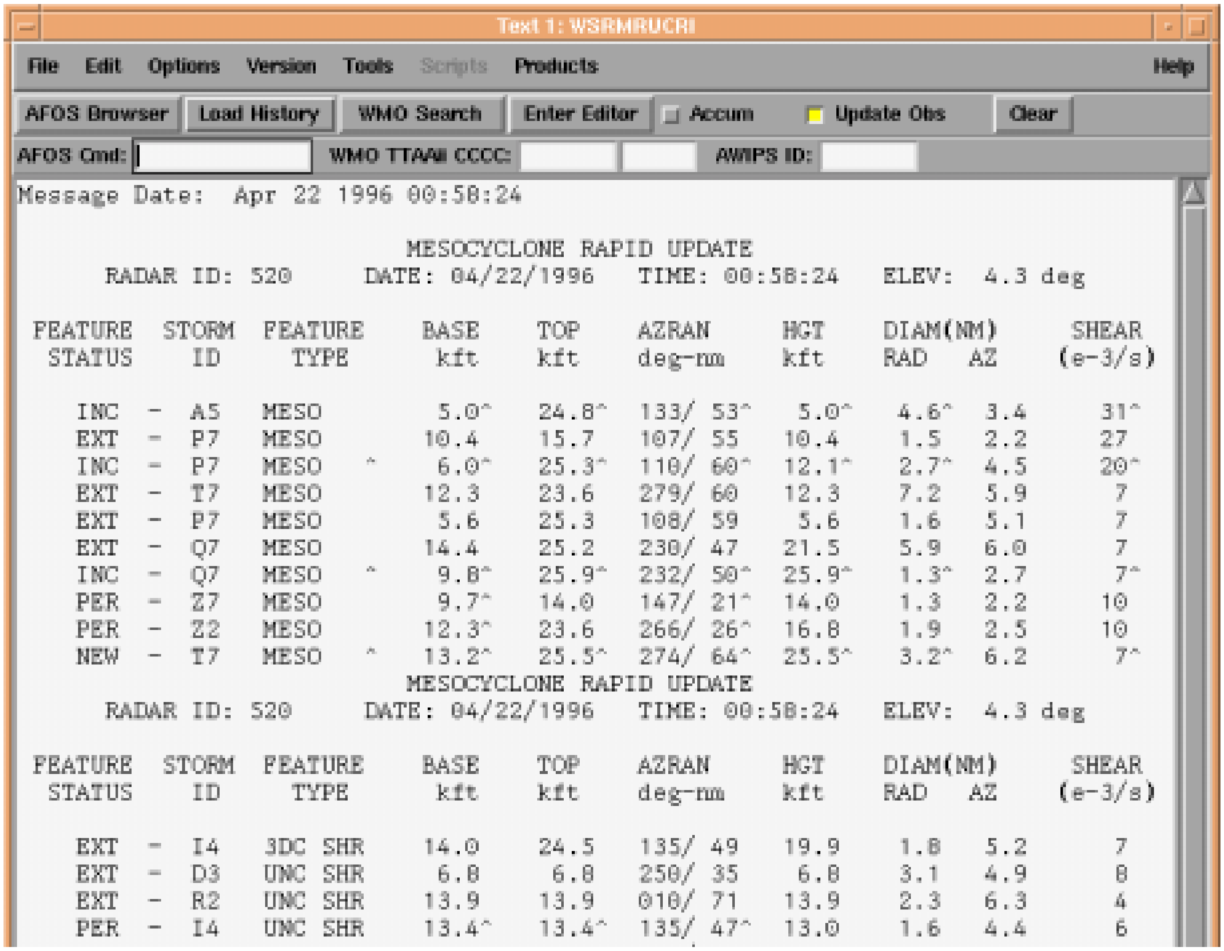
In Table 4-1, storm A0 has two MESOs identified; one is persistent (PER) and the other is increasing (INC). Note that the attribute information for the PER MESO at 307°/46 nm has no ^ symbols. This indicates that the attribute information is all from the previous volume scan. For the INC MESO at 303°/39 nm, there are ^ symbols next to the MESO, AZ RAN, BASE TOP, RAD AZDIA. This indicates that all of these attributes have been updated with current volume scan information. The INC status means that either the shear or the feature type has increased since the previous volume scan.

Storm U1 has a MESO that is extrapolated (EXT). The MRU has not yet matched this previous volume scan feature with current volume scan data.

MRU Alphanumeric Product

The MRU Alphanumeric Product provides storm attribute information similar to the Graphic Attribute Table, with the addition of Uncorrelated Shears and the Shear value. At the AWIPS text window, the product name is WSRMRUXXX.

In Figure 4-31, the MRU alphanumeric product has the output for a 4.3° MRU product. The features are displayed in groups of ten, and ordered by feature type.



Text 1: WSRMRUCRI

File Edit Options Version Tools Scripts Products Help

AFOS Browser | Load History | WMO Search | Enter Editor | Accum | Update Obs | Clear

AFOS Cmd: | WMO TTAAII CCCC: | AWIPS ID:

```
Message Date:  Apr 22 1996 00:58:24

                        MESOCYCLONE RAPID UPDATE
      RADAR ID: 520     DATE: 04/22/1996   TIME: 00:58:24   ELEV:  4.3 deg

 FEATURE  STORM  FEATURE     BASE    TOP    AZRAN     HGT   DIAM(NM)    SHEAR
  STATUS   ID     TYPE       kft     kft    deg-nm    kft   RAD   AZ   (e-3/s)

   INC   -  A5   MESO        5.0^   24.8^  133/ 53^   5.0^   4.6^  3.4    31^
   EXT   -  P7   MESO       10.4    15.7   107/ 55   10.4    1.5   2.2    27
   INC   -  P7   MESO   ^    6.0^   25.3^  110/ 60^  12.1^   2.7^  4.5    20^
   EXT   -  T7   MESO       12.3    23.6   279/ 60   12.3    7.2   5.9     7
   EXT   -  P7   MESO        5.6    25.3   108/ 59    5.6    1.6   5.1     7
   EXT   -  Q7   MESO       14.4    25.2   230/ 47   21.5    5.9   6.0     7
   INC   -  Q7   MESO   ^    9.8^   25.9^  232/ 50^  25.9^   1.3^  2.7     7^
   PER   -  Z7   MESO        9.7^   14.0   147/ 21^  14.0    1.3   2.2    10
   PER   -  Z2   MESO       12.3^   23.6   266/ 26^  16.8    1.9   2.5    10
   NEW   -  T7   MESO   ^   13.2^   25.5^  274/ 64^  25.5^   3.2^  6.2     7^
                        MESOCYCLONE RAPID UPDATE
      RADAR ID: 520     DATE: 04/22/1996   TIME: 00:58:24   ELEV:  4.3 deg

 FEATURE  STORM  FEATURE     BASE    TOP    AZRAN     HGT   DIAM(NM)    SHEAR
  STATUS   ID     TYPE       kft     kft    deg-nm    kft   RAD   AZ   (e-3/s)

   EXT   -  I4   3DC SHR    14.0    24.5   135/ 49   19.9    1.8   5.2     7
   EXT   -  D3   UNC SHR     6.8     6.8   250/ 35    6.8    3.1   4.9     8
   EXT   -  R2   UNC SHR    13.9    13.9   010/ 71   13.9    2.3   6.3     4
   PER   -  I4   UNC SHR    13.4^   13.4^  135/ 47^  13.0    1.6   4.4     6
```

Figure 4-31. Alphanumeric MRU product.

Significance of ^ Symbol

The graphical (Table 4-1) and alphanumeric (Figure 4-31) attribute tables essentially offer a comparison of previous vs. current volume scan information. The design philosophy of the MRU is to provide the attribute information for the current or previous volume scan, dependent on which has the higher strength. The ^ symbol denotes attribute information that has been updated to the current volume scan.

- Any feature that has a status of INC will show the updated strength attributes for the current volume scan, indicated by the ^ symbol. An INC feature with a MESO ^ as its feature type means the feature has just increased to MESO status within the current volume scan. ***This***

increase in status does not necessarily mean that the circulation has intensified. Better symmetry of 2D circulations due to radar sampling can also result in the change in status from 3D SHR to MESO.

- A feature that is PER has been matched from the previous volume scan, but its attributes have not been updated. **They will be updated for the current volume scan only if the max shear or feature type increases.** If these attributes stay the same or decrease, you will continue to see the attributes from the previous volume scan.

Highest Elevation MRU vs. Legacy Meso

One might expect that the output for the highest elevation MRU product would be identical to the end of volume Meso product. However, there may differences due to the design philosophy of the MRU. The MRU is designed to display the “worst case scenario” until the final Meso product is generated.

If the feature type or max shear has ***increased*** for a volume scan, the MRU depicts its new value, which is then displayed in the final Meso product as well. For example, if a 3D SHR has increased to a MESO, MRU will denote this by MESO ^, and the end of volume Meso product will depict it as a MESO as well.

However, if the feature type or max shear has ***decreased*** for a volume scan, the MRU will continue to display the higher value from the previous volume scan. The feature type or shear will only be downgraded on the end of volume Meso product. For example, if a feature has decreased from MESO to 3D SHR, it will be depicted as a MESO on the 19.5° MRU, but as a 3D SHR on the Meso product.

MRU One Time Request

The AWIPS One Time Request screen for MRU has an option for obtaining the lowest “n” elevation angles with a single request. In Figure 4-32, the lowest six elevations have been selected.

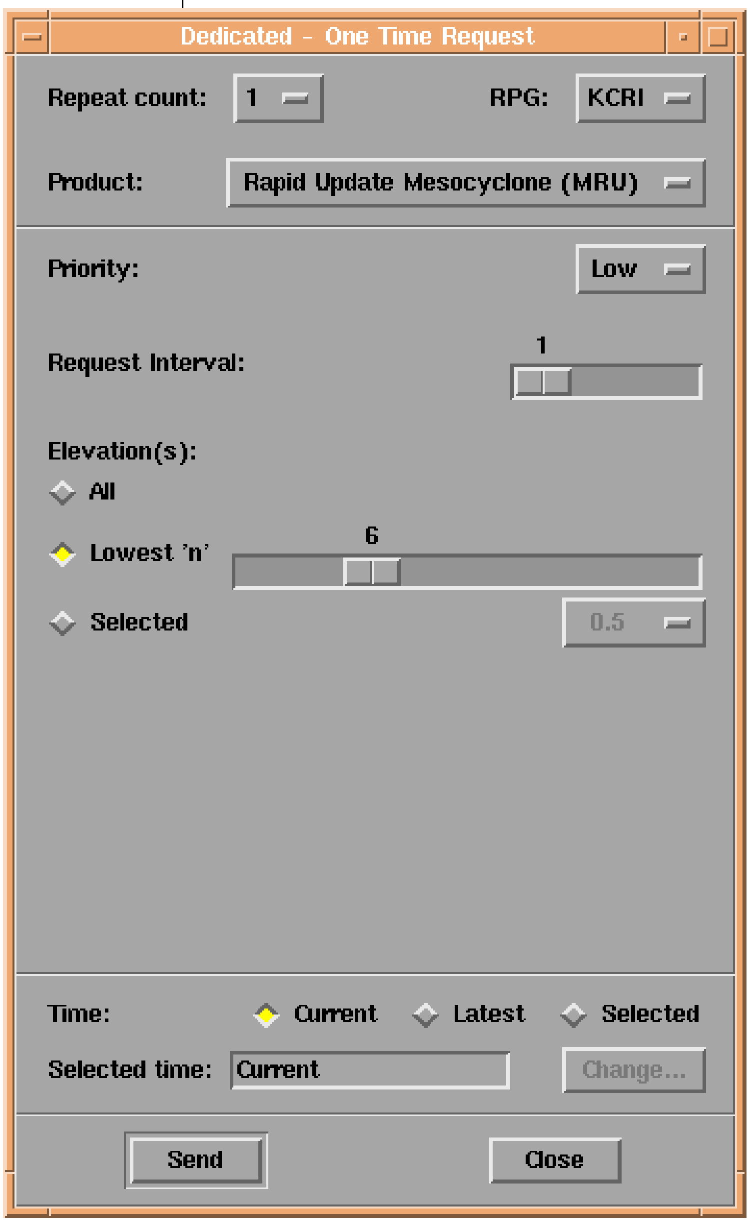


Figure 4-32. AWIPS request window for the MRU product. Note the option to select the lowest “n” elevations, which will provide multiple elevations of the MRU from a single request.

MRU RPS List

The MRU product can be placed on an RPS list with options similar to the One Time Request. The elevations specified can be all, a specific angle, or the lowest “n”. In Figure 4-33, all three options are displayed when adding the MRU to the RPS list.

Note that the option for the lowest six elevations has been selected. Figure 4-34 shows the resultant RPS list entries.

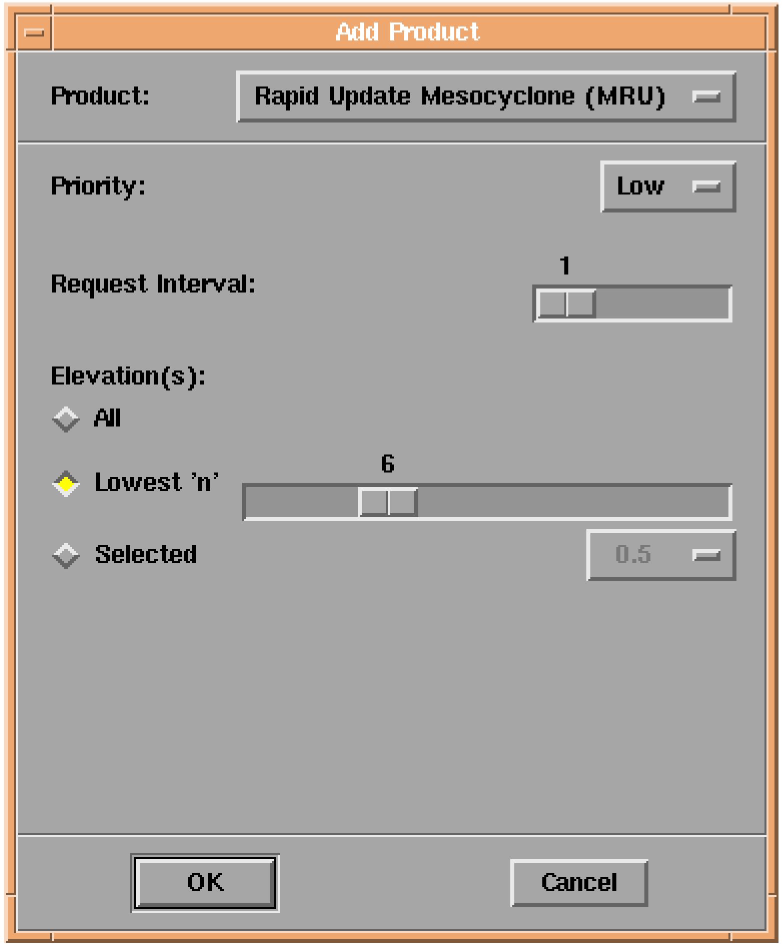


Figure 4-33. Example of the window to add the MRU product to an RPS list. Note that options for all or the lowest "n" elevations allow for multiple elevations of the MRU from a single RPS entry.

MRU Operational Considerations

The best use of the MRU will likely result from generating the minimum number of the lowest "n" elevations that is sufficient to assess potential circulations early in the volume scan. The optimal choice for "n" will likely change from event to event, and is dependent on a number of considerations.

Range of storms

If storms are at a short range to the RDA, mesocyclone detection may require numerous elevation angles.

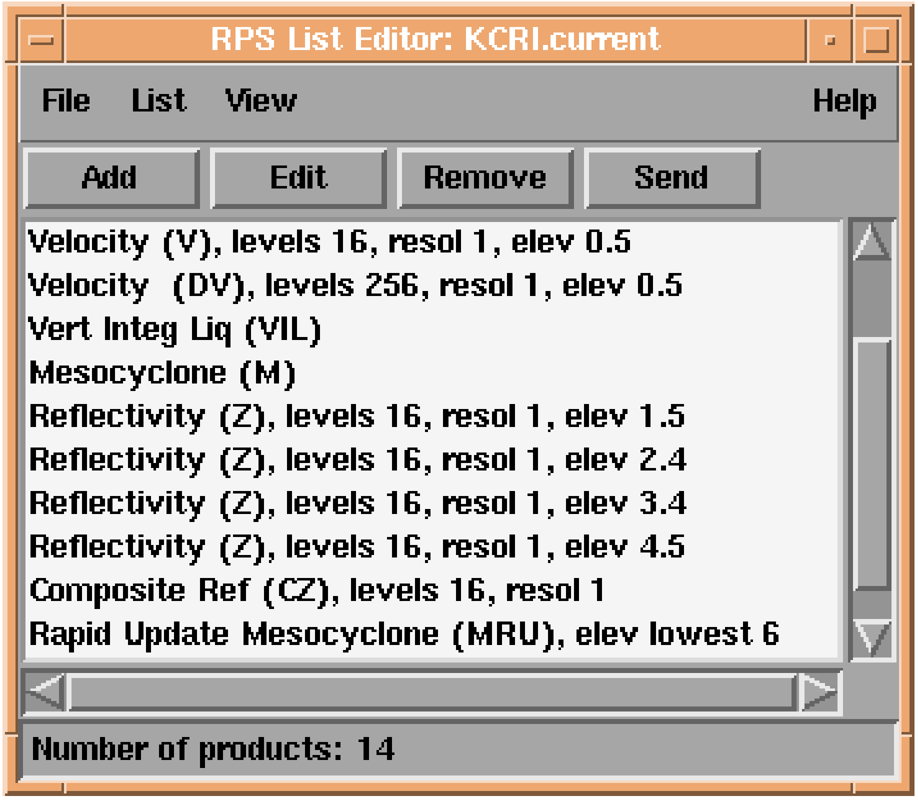


Figure 4-34. Example of the MRU product as part of an RPS list. Note the lowest six elevations will be generated from a single RPS list entry.

If storms are at mid ranges, the lowest “n” elevations of the MRU that may be preferable will depend on the VCP and the depth of the storm.

If storms are at long range, the ability of the Mesocyclone Algorithm to detect a circulation is minimized. The detections possible for the MRU would be impacted in the same way.

Depth of storms

In addition to the range, the depth of storms would also impact the best choice for the lowest “n” elevations.

MRU Limitations

1. **Classification as Increasing or Persistent may be the result of sampling issues versus a change in the actual attributes of the feature**. For example, the size of the circulation with respect to beamwidth can affect a feature

change from 3D SHR to a MESO (e.g. symmetry of 2D circulations has improved) when in fact the circulation has not really intensified.

2. The MRU graphical attribute table and alphanumeric attribute table contain attributes from both previous and current volume scan information (**includes ^ symbol**).
3. **Feature matching ability dependant on motion supplied by SCIT algorithm.** Incorrect storm motion will result in improper or no matching.

MRU Strengths/Applications

1. **Intermediate algorithm output is available before end of volume scan.**
2. **MRU tracks features to develop time continuity.**

Tornadic Vortex Signature (TVS)

Review of Operator Identified TVS

Modified NSSL TVS Definition

An intense gate-to-gate azimuthal shear associated with tornadic-scale rotation. A TVS is identified if the gate-to-gate shear is:

$\geq$ 90 kts and the range is < 30 nm

$\geq$ 70 kts and the range is 30 nm $\leq$ r < 55 nm

Gate-to Gate Shear = Velocity Difference = **|** velocity inbound **|** + **|** velocity outbound **|**

Remember that these values are only guidelines, the user will have to adjust according to the situation and geographic location.

Tornado Detection Algorithm (TDA)

The Tornado Detection Algorithm (TDA) is designed to detect significant shear regions in the atmosphere. The TDA uses multiple velocity thresholds to locate shear regions, and classifies these regions according to altitude and strength.

The Mesocyclone and Tornado Detection algorithms process data separately. This means that ***an algorithm-identified mesocyclone need not exist for a TVS or Elevated TVS (ETVS) to be identified.*** The TDA is modeled after the SCIT algorithm and uses a three step process to identify circulations.

TDA Process

First, 1-D pattern vectors are identified on each elevation slice. In TDA, a pattern vector is a region of gate-to-gate shear, which means the velocity difference is calculated between range bins ***located on adjacent azimuths*** at the same range. A minimum shear value is required for a pattern vector to be identified (see Fig. 4-35). The TDA searches only for patterns of velocity indicating cyclonic rotation. It ***does not*** detect an anticyclonically rotating signature.

Next, 2-D features are created by combining the 1-D pattern vectors (see Fig. 4-36). At least three pattern vectors (default) are needed to declare a 2-D feature.

TDA uses six velocity difference thresholds to identify pattern vectors. This technique allows the algorithm to isolate core circulations which may be embedded within regions of long azimuthal shear. An example would be a radially oriented gust front or squall line. In Figure 4-37, a long segment of shear exceeding 15 m/s has embedded within it a smaller segment of shear greater than 20 m/s, and

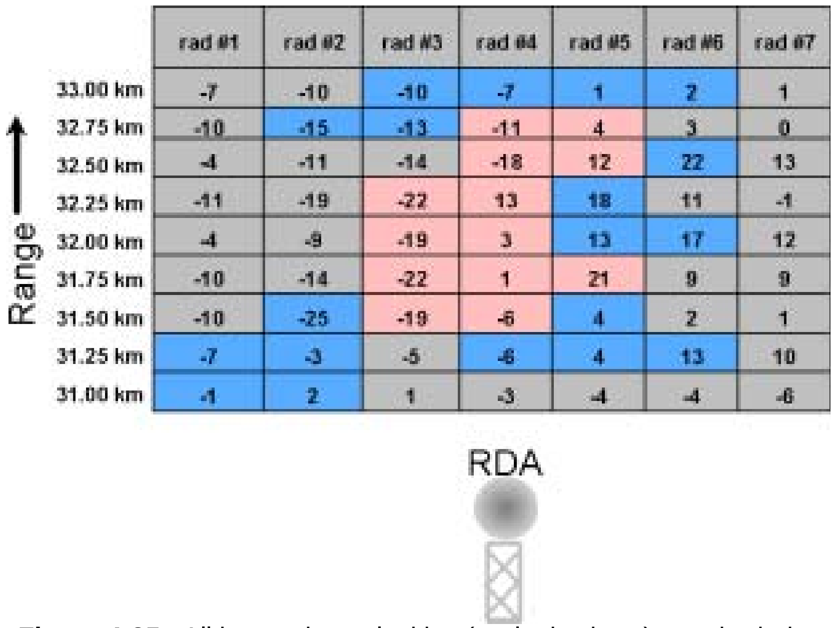


Figure 4-35. All increasing velocities (cyclonic shear) are shaded blue. All TDA Pattern Vectors (>11 m/s shear) are shaded pink.

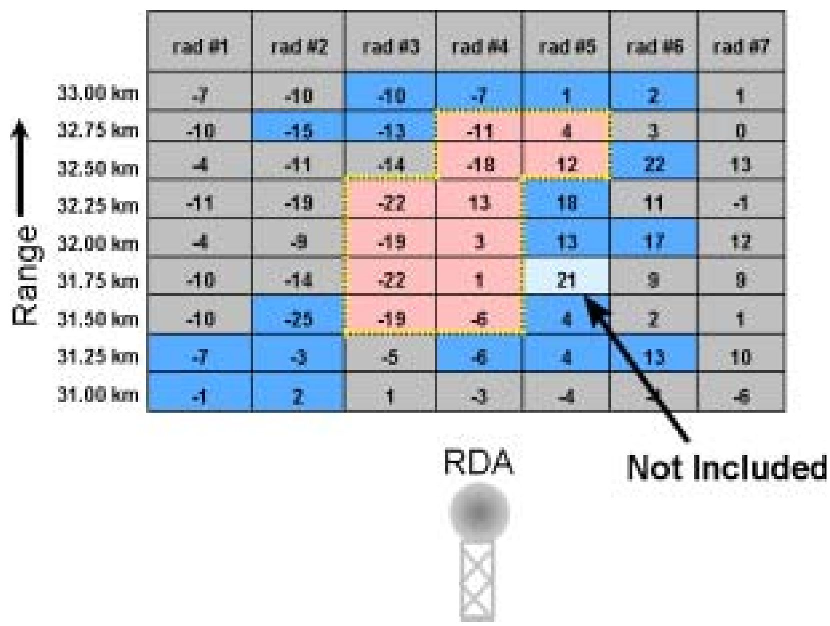


Figure 4-36. 2-D Feature outlined in yellow.

still smaller segments of shear greater than 25 m/s. If a 2-D feature passes a symmetry test (length to width ratio within a specified limit), it is declared a 2-D circulation.

Finally, 3-D features are created by vertically correlating the 2-D circulations identified at each ele-

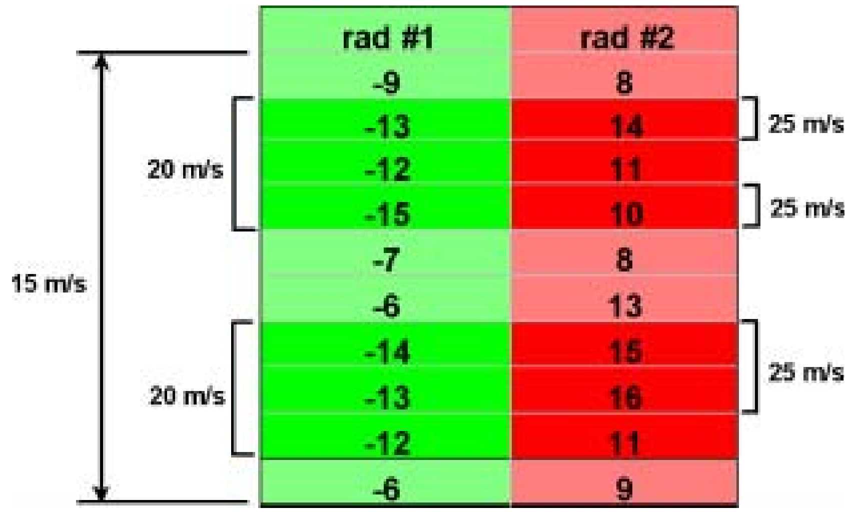


Figure 4-37. 2-D Features - Multiple velocity thresholds used to identify stronger shear embedded within weaker shear.

vation (see Fig. 4-38). Processing begins by correlating the strongest 2-D circulations first, then moving to progressively weaker circulations. If a feature contains at least three vertically correlated 2-D circulations, it is declared a 3-D circulation, and identified as either a TVS or an ETVS. Ideally, there will be no gaps in elevation angles between the vertically correlated 2-D circulations. However, a one elevation angle gap is permitted to account for base data problems such as range folding and velocity dealiasing failures.

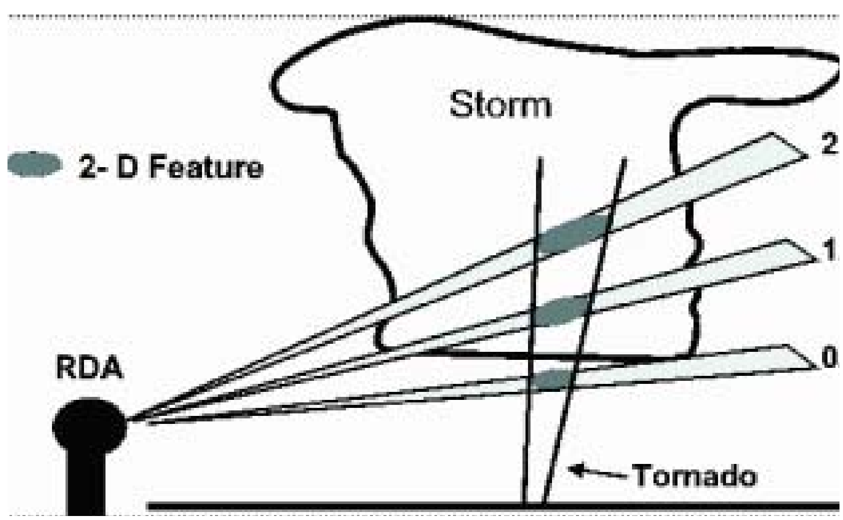


Figure 4-38. Vertically correlated 2-D circulations.

TDA Adaptable Parameters

There are a number of TDA adaptable parameters. Six of these parameters ar under URC Level of Change Authority. A more in-depth look at these adaptable parameters is available in the RPG Adaptable Parameters Handbook Section 6.15 (http://www.roc.noaa.gov/ssb/sysdoc/manuals/Operations_TMS/AporpgSCR1.pdf).

Three of the adaptable parameters are changed as a set (default value in parenthesis):

- Minimum 3D Feature Depth (1.5 km)
- Minimum Low Level Delta Velocity (25 m/s
- Minimum TVS Delta Velocity (36 m/s)

The other three can be set independently based on URC preference:

- Minimum Reflectivity (0 dBZ)
- Maximum Pattern Vector Range (100 km)
- Maximum Number of ETVS's (0)

Definitions and Symbology

TVS

A Tornadic Vortex Signature, TVS, is defined as a 3-D circulation with a base located on the 0.5° slice ***or*** below 600 meters ARL (above radar level). The depth of the circulation, maximum delta velocity anywhere in the circulation, and the delta velocity at the base of the circulation must exceed the adaptable parameters set (see previous section). The TVS symbol is displayed on the graphic product and overlay as a red, filled, inverted triangle. TVS symbols are placed at the azimuth and range of the lowest 2-D feature.

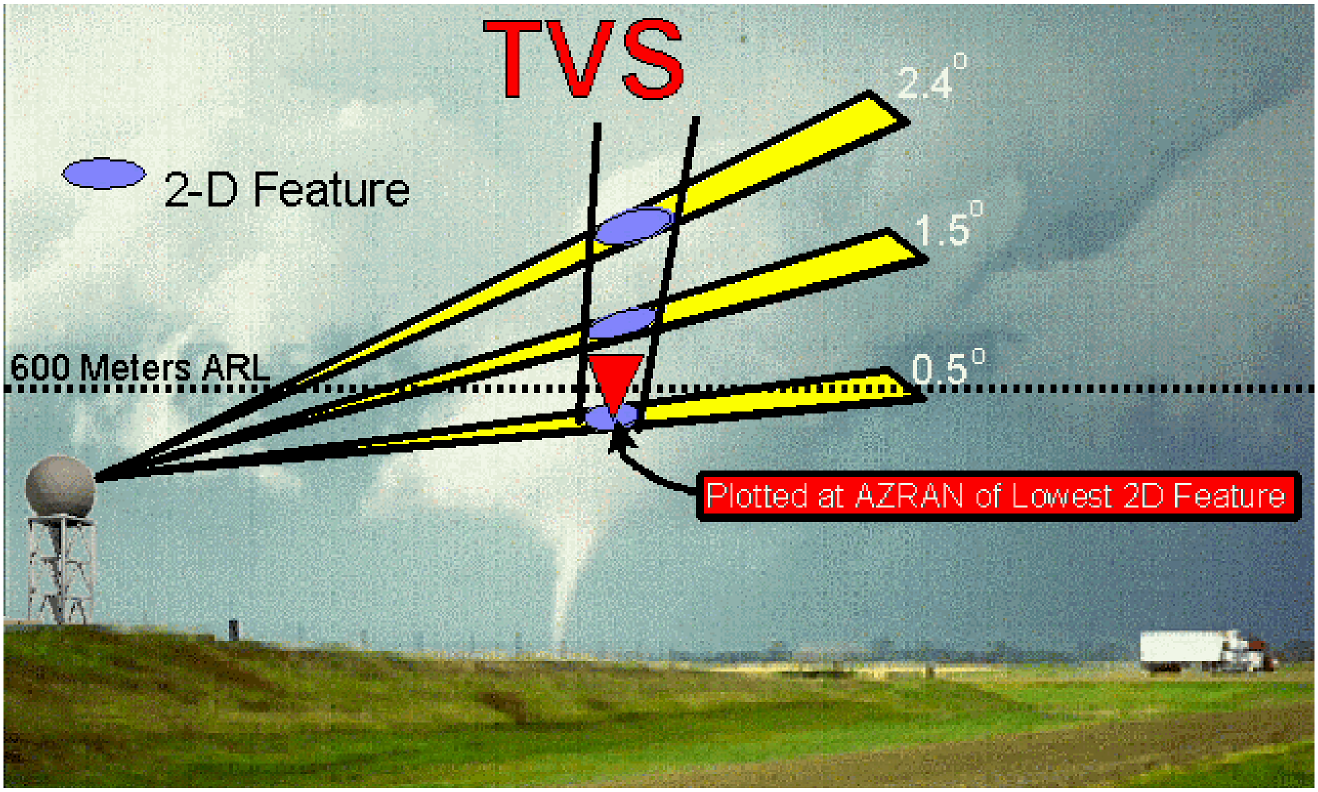


Figure 4-39. TVS definition.

ETVS

An Elevated Tornadic Vortex Signature, Elevated TVS or ETVS, is defined as a 3-D circulation with a base above the 0.5° slice ***and*** above 600 meters ARL. The depth of the circulation must be at least 1.5 km. Additionally, the thresholds of depth, max delta velocity and low level delta velocity must be exceeded. The ETVS symbol is displayed on the TVS overlay and the TVS graphic product as a red, open, inverted triangle as shown in Figure 4-41, and is placed at the azimuth and range of the lowest 2-D feature

Note that an Elevated TVS may possess a larger value of maximum shear somewhere in the storm column as compared to a TVS, but if there is no circulation on the 0.5° slice or below 600 meters, it cannot be defined as a TVS, despite possessing the higher shear.

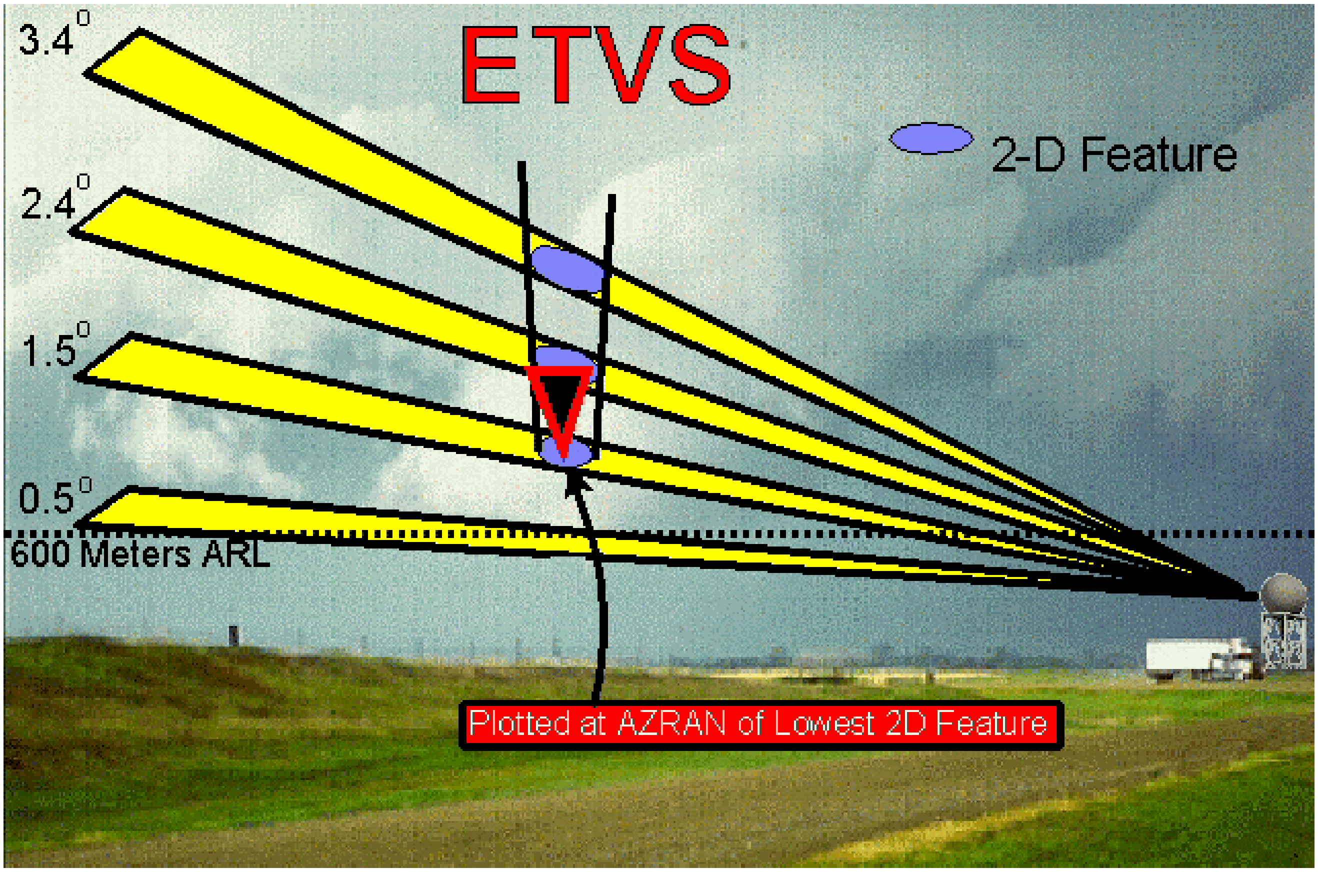


Figure 4-40. ETVS definition.

TVS Product Parameters

See Figure 4-41 for an example of the TVS product

TVS product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Tornado Vortex Signature
- PAGE #: This is the page number of the attribute table.
- DATE: Day of week, time, and date in UTC

TVS product annotations

- TVS Attribute Table

Additional TVS product characteristics

- RANGE: 124 nm

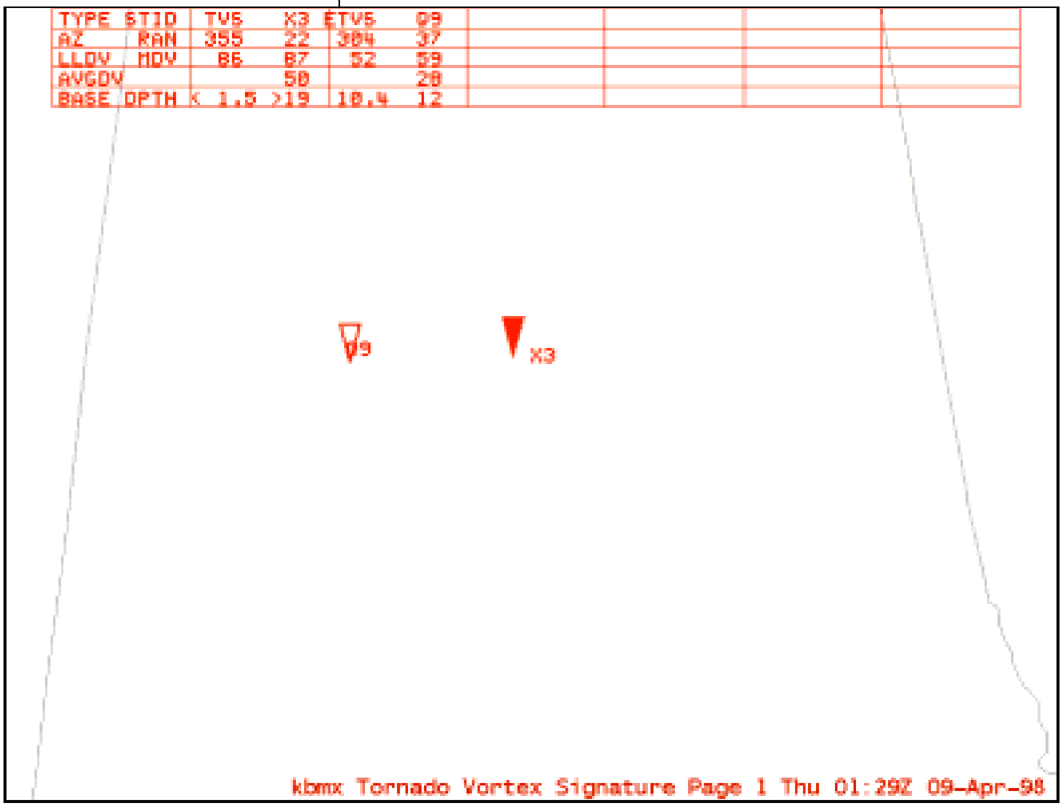


Figure 4-41. Example of TVS graphic product.

TVS Attribute Table

The TVS Attribute Table is available if any TVSs or ETVSs are detected. See Figure 4-42.

TYPE	STID	TVS	X3	ETVS	Q9
AZ	RAN	355	22	304	37
LLDV	MDV	86	87	52	59
AVGDV			50		28
BASE	DPTH	<1.5	>19	10.4	12

Figure 4-42. TVS Attribute Table which appears at the top of the TVS product.

Definitions

- **LLDV**: Low-Level Delta Velocity, in knots (Greatest velocity difference of lowest 2-D circulation)
- **MDV**: Maximum Delta Velocity, in knots (Greatest velocity difference of any 2-D circulation)

- **AVGDV**: Average Delta Velocity, in knots (Average weighted velocity difference of all 2-D circulations)
- **BASE**: Lowest altitude of the 3-D circulation, in Kft (Altitude of the lowest 2-D circulation)
- **DPTH**: Depth of the 3-D circulation, in Kft (Height difference between the lowest and highest 2-D circulation)

If a circulation exists at either 0.5° or 19.5°, then the depth of the circulation (DPTH) is estimated, and a > (greater than) symbol will be displayed with the stated depth. Similarly, if the circulation exists at 0.5°, the base (BASE) of the circulation is estimated, and a < (less than) symbol will be used with the stated base altitude. (See Figure 4-41)

TVS Alphanumeric Product

The TVS Adaptation Data can be displayed at the AWIPS Text Display Window (WSRTVSxxx). This can be used to determine the adaptable parameter settings used to generate the product. See Figure 4-43.

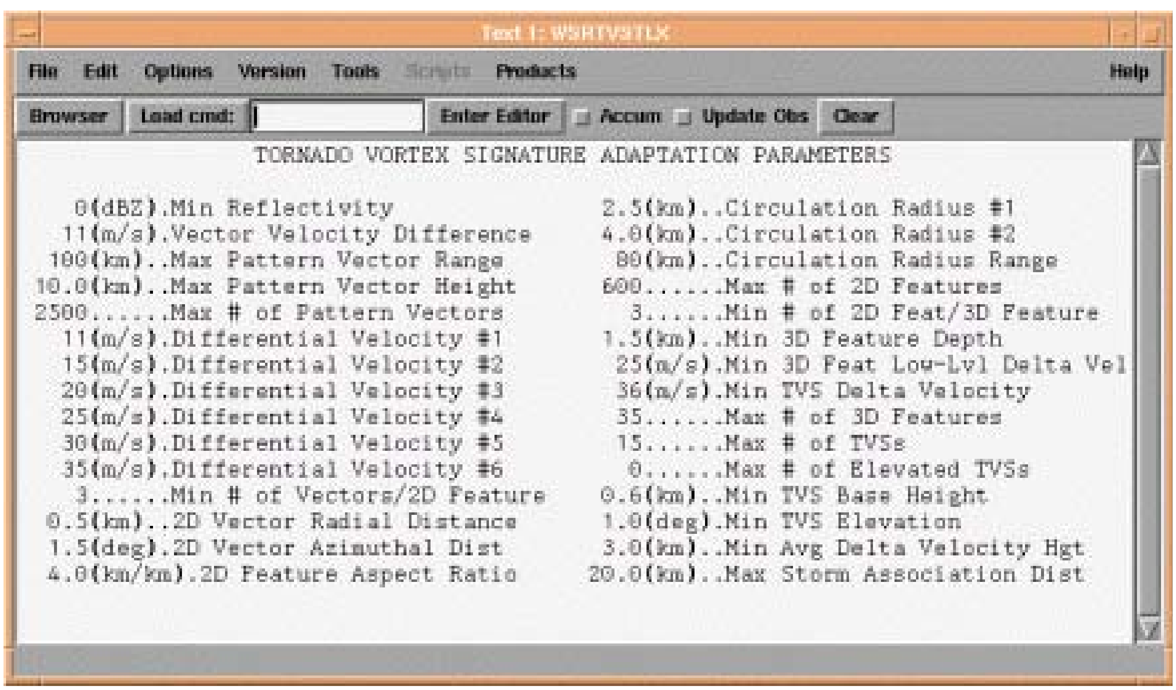


Figure 4-43. TVS adaptable parameters displayed at the AWIPS Text Display Window.

Radar Display Controls (ETVS Display Toggle)

Depending on which adaptable parameter settings are invoked, it is possible to have a situation when the display becomes cluttered with Elevated TVS symbols, making product interpretation difficult. For this reason, operators have been given control over whether or not ETVS symbols are displayed on the TVS graphic product and overlay.

This toggle does not affect the TVS attribute table or the TVS alphanumeric product or other AWIPS workstations. It is a graphic display function only. If the ETVS symbol is toggled to “off”, a situation could arise where outside users are getting ETVSs, but the AWIPS graphic product is not displaying this information.

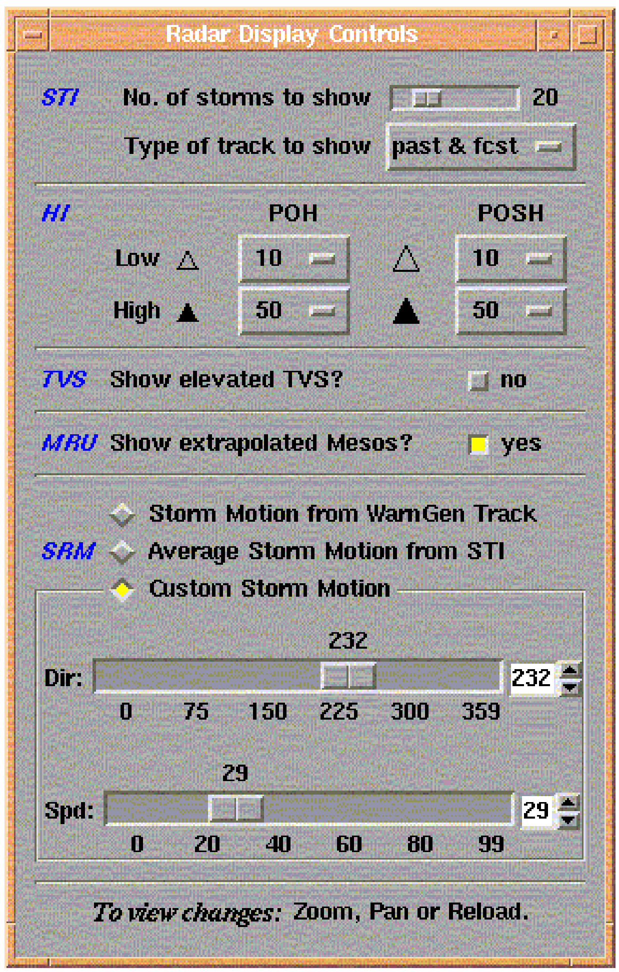


Figure 4-44. Radar Display Controls Edit Screen.

Operational Considerations

When a TVS detection occurs, consider the environmental wind and thermal profile, the signatures position in relation to the storm with which it is associated, time continuity, and the storm's range from the radar. Beyond about 60 km, the TVS will most likely be triggered by a strong mesocyclone and not all mesocyclones produce a tornado. Since the TDA works independently of the mesocyclone algorithm, the detection of a mesocyclone coincident with the TVS may support issuing a tornado warning. If the TVS is adjacent to a strong reflectivity gradient especially near the back of a storm, near a notch on the right rear flank of a storm, or near the tip of an appendage attached to the right rear flank of a storm, then the forecaster should give greater consideration to issuing a tornado warning.

Because of its sensitivity, the TDA shows continuity in time and space. TVS detections for the same storm on two or more consecutive volumes can suggest the validity of issuing a tornado warning. The TDA has identified TVSs nearly continuously on long-lived supercells typical of the Great Plains, especially ones that cyclically produce tornadoes. In the South and the Southeast, tornadoes may be embedded within squall lines. The TDA tends to identify TVSs near the bend in a line echo wave pattern along the interface between warm moist inflow and storm outflow. While many of the TVSs are false alarms, tornadoes do occasionally spin up under these conditions.

Elevated TVSs are routinely generated by the TDA, but naturally do not score statistically as well as TVSs. However, ETVSs may be used as indicators of rotation aloft that could, with sufficient vorticity near the ground, produce a tornado. That is, they can be used to provide better lead times for identifying storms with the potential to produce tornadoes. A second use is to fill in gaps in TVS detections. Sometimes vertical continuity cannot be established between the lowest elevation and higher elevations. Other times ground clutter or range folding precludes measuring high gate-to-gate velocity differences. An elevated TVS may provide the time continuity to give a forecaster confidence to issue a tornado warning. ***One should be cautious about issuing a tornado warning based solely on ETVSs.***

Remember that algorithms serve to provide users with guidance. Ultimately, the decision to issue or not to issue a warning is up to the individual forecaster using all available data, including spotter reports.

TVS Limitations

1. **Adaptable parameters need more research.** Parameters which work well in one type of meteorological setting may not be as effective in other situations.
2. **High false alarm rates especially in squall lines and tropical cyclones.** A high FAR with TDA may result in over-warning, or desensitizing forecasters.
3. **Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs.** Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

TVS Strengths/Applications

1. The algorithm searches for gate-to-gate shear, which is related to tornadic circulations.
2. Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions.

3. A distinction is made between different types of shears (TVS vs. ETVS, delta velocity calculations), and more information is provided about the base and depth of circulations.
4. The algorithm, through a large number of adaptable parameters, allows fine-tuning of algorithm performance, resulting in a higher probability of detecting operationally important shear regions.

Interim Summary

Mesocyclone Product

1. A signature from the Mesocyclone product must be investigated for validity.
2. If a mesocyclone is detected in the velocity field before the algorithm, don't wait for a mesocyclone symbol from the algorithm to take the appropriate action.
3. Adaptable parameters will need to be adjusted to various climatological regimes.

Mesocyclone Rapid Update (MRU)

1. Updated every elevation scan.
2. Uses SCIT algorithm to track features.
3. Feature classified as Persistent, Increasing, Extrapolated, or New.

TVS Product

1. The TVS product can be useful in alerting the operator of significant and possibly tornadic circulations.
2. Output and performance are highly dependent on the parameter sets used.

Lesson 5: Precipitation Algorithms and Products

This lesson will present the precipitation products generated by the WSR-88D, and the algorithms which produce them.

It is important for operators to have a basic understanding of the precipitation algorithms and how they affect the WSR-88D precipitation products.

Objectives

Without references, in accordance with standardized instruction, you will be able to:

a. Identify the strengths and limitations of the Precipitation Processing Subsystem.

b. Describe the precipitation products produced by the Precipitation Processing Subsystem.

c. Identify the applications and limitations of the Precipitation products.

Precipitation Algorithms Section

Overview

Precipitation Detection Function

Precipitation Processing Subsystem

1. Preprocessing

2. Rate

3. Accumulation

4. Adjustment

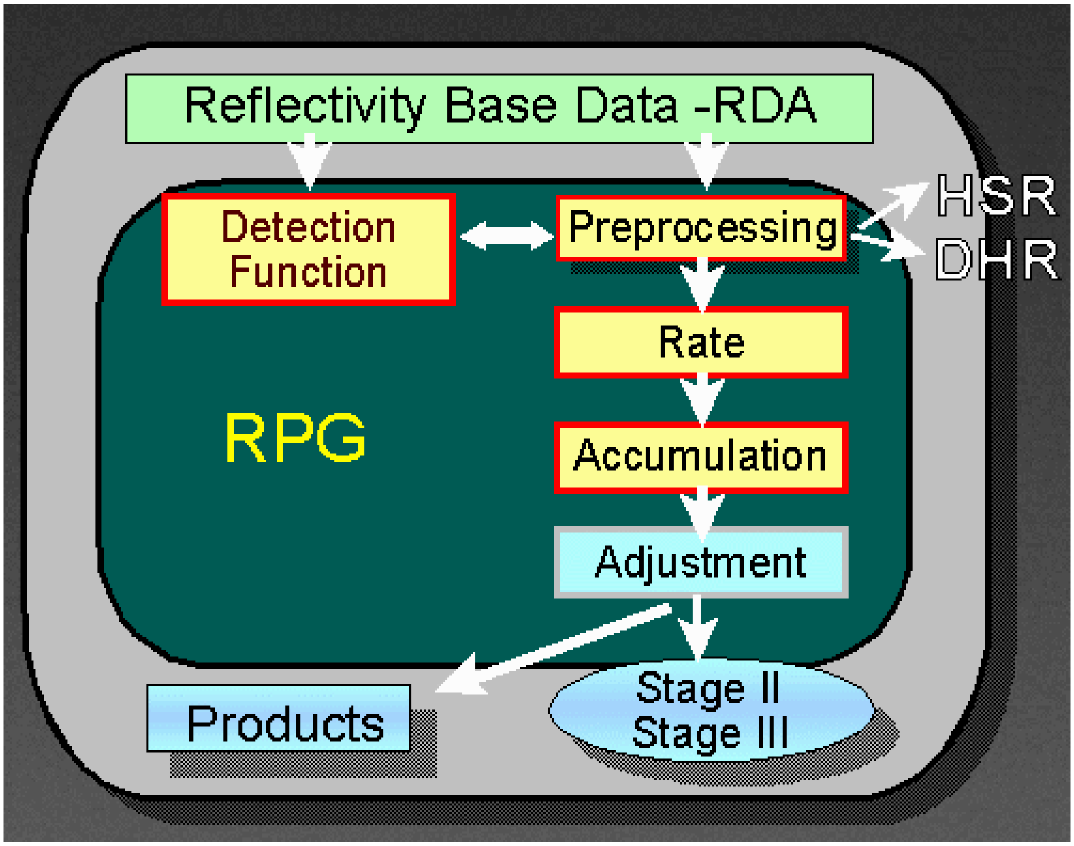


Figure 5-1. WSR-88D Precipitation Processing

Precipitation Detection Function

The purpose of the Precipitation Detection Function (PDF) is to determine if precipitation is occurring within 124 nm of the radar. It utilizes the lowest four elevation angles of the Base Reflectivity Data.

Precipitation Category Thresholds

There are three thresholds used by the PDF.

Precipitation Rate Threshold

Precipitation Rate Threshold (in dBR) - This is echo intensity. At the RPG HCI, the units are in dB of rainfall rate. For better understanding, we will use the dBZ equivalent of these thresholds. This threshold is ***not*** editable.

Precipitation Area Threshold

Precipitation Area Threshold (in km^2) - This is the allowable areal coverage of precipitation-like return without activating the precipitation algorithms. This threshold is ***not*** editable.

Nominal Clutter Area (NCA) Threshold

Nominal Clutter Area (NCA) Threshold (in km^2) - This value is to be used to account for ***residual clutter*** contamination whose reflectivity exceeds the precipitation rate threshold. This value ***is*** editable.

Each volume scan, intensity and areal coverage of the reflectivity data (lowest 4 slices), is compared to these thresholds. In order for the algorithms to begin accumulating nonzero precipitation, the intensity and areal coverage must equal or exceed the Precipitation Rate Threshold, ***and*** the Area Threshold (the ***sum*** of the Precipitation Area Threshold and Nominal Clutter Area)

While all three parameters are adaptable, the Precipitation Rate and Area Thresholds are ROC controlled, while the Nominal Clutter Area Threshold is URC controlled.

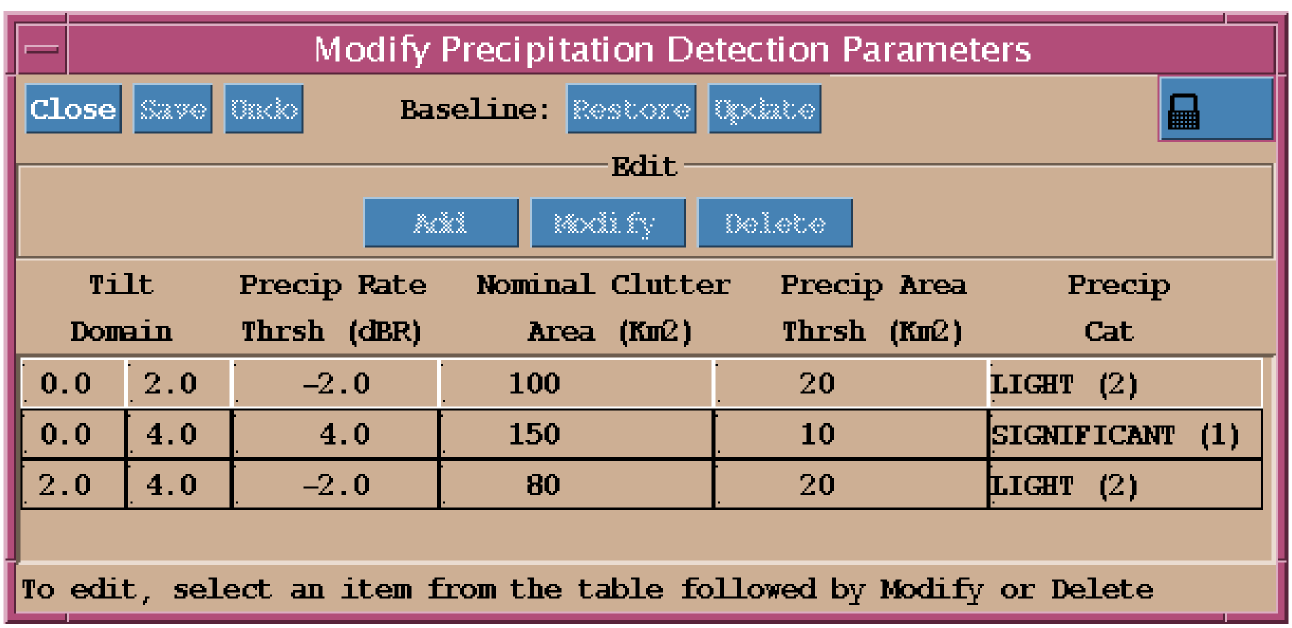


Figure 5-2. Precipitation Detection Function screen at the RPG HCI. The Nominal Clutter Area should be used to account for the areal coverage of residual clutter.

Category Detection vs Assignment

A category ***detection*** means that the rate and areal coverage thresholds for that category have been equaled or exceeded for the current volume scan. It does not necessarily mean that the particular category has been ***assigned***. For any particular volume scan, the category that is assigned will control which VCP may be available.

Precipitation Categories Assigned

Each volume scan, a precipitation category number is ***assigned***.

Category 0

Category 0 is defined as no precipitation within 124 nm of the RDA ***in the past hour***. No thresholds are met or exceeded. Once category 0 has been ***assigned***:

VCP Changes

1. If the WSR-88D is in a Clear Air Mode VCP, it will remain there.
2. If the WSR-88D is in a Precipitation Mode VCP, it can be manually switched back to a Clear Air Mode VCP.

Note that since category 0 is defined as no precipitation ***in the past hour***, one hour will elapse from the time that category 0 is ***detected*** to the time that it is ***assigned***. Once category 0 is assigned, as far as the Precipitation Processing Subsystem is concerned, it's not raining, so the algorithms will be accumulating zeros.

Category 1

Category 1 is defined as significant precipitation within 124 nm of the RDA ***in the past hour***. Significant precipitation may include high precipitation intensities over small areas or low precipitation intensities over large areas. The rainfall is significant from a hydrologic standpoint, where accounting for water in the soil and on the surface becomes important.

Category 1 Thresholds

The thresholds for category 1 are:

- Precipitation Rate Threshold of 4 dBR = 30 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 10 km^2 and the Nominal Clutter Area

VCP Changes

When the category 1 thresholds are equalled or exceeded, then category 1 is assigned. For the volume scan where category 1 is ***initially assigned***, there are two possible outcomes:

1. If the WSR-88D is in a Precipitation Mode VCP, the precipitation algorithms will be executed, and the radar will stay in its current VCP.

2. If the WSR-88D is in a Clear Air Mode VCP, a VCP restart with an automatic switch to VCP 21 occurs, and the precipitation algorithms are executed.

Note that since category 1 is defined as significant precipitation ***in the past hour***, category 1 will continue to be ***assigned*** for up to one hour after it is no longer ***detected***.

Category 2

Category 2 is defined as light precipitation within 124 nm of the RDA ***in the past hour***. This may include isolated very weak convection or low intensity widespread events.

Category 2 Thresholds

The thresholds for category 2 are:

- Precipitation Rate Threshold of -2 dBR = 22 dBZ
- Threshold Area is the sum of the Precipitation Area Threshold of 20 km^2 and the Nominal Clutter Area

VCP Changes

For volume scans where category 2 is ***assigned***, there is no automatic VCP change, and the algorithms are executed. Category 2 allows accumulations in any VCP, including the Clear Air Mode VCPs.

Note that since category 2 is defined as light precipitation ***in the past hour***, category 2 will continue to be ***assigned*** for up to one hour in category 0 ***(detected)***.

Clear Air and Precipitation Detection

At times, such as a snow event, Clear Air mode reflectivity data may be desired. VCPs 31 or 32 will display the lower reflectivities down to -28 dBZ. By raising the Nominal Clutter Area for ***only*** category 1, and leaving the Nominal Clutter Area low for Category 2, precipitation thresholds (Rate and Area) will be exceeded for category 2, but the thresholds (Rate and Area) will ***not*** be exceeded for category 1. Since the thresholds for category 2 and not category 1 have been exceeded, the precipitation is considered by the radar to be category 2. The radar can be run in VCPs 31 or 32, display lower reflectivities, and still accumulate precipitation in the precipitation products.

This method may be advantageous when trying to detect boundaries within your county warning area, and precipitation may be occurring outside your county warning area. This will allow you to keep the radar in a more sensitive VCP, while precipitation products will still be generated for other users, such as River Forecast Centers.

Word of Warning

This method must be used with care however. The potential exists for significant storms to develop, without the automatic switch to VCP 21. Do not leave the Nominal Clutter Area for category 1 at a high setting for long periods of time. If storms exceed the reflectivity threshold for category 1, the radar will not automatically switch to VCP 21 unless the areal coverage is also satisfied. It is therefore critical that the nominal clutter area is checked when beginning each shift.

Raising ***both*** category 1 and category 2 nominal clutter areas is ***not*** the proper way to keep the radar out of Mode A during Anomalous Propagation. The base data will still be contaminated by the AP unless it is suppressed at the RDA. If returns due to AP are causing the radar to exceed category 1 or category 2 thresholds, then invoking a Clutter Suppression Region at the RPG HCI is the appropriate way to mitigate that problem.

Precipitation Detection Status Screen

The Precipitation Detection Status Screen at the RPG HCI (Figure 5-3) contains information relating to the Precipitation Detection Function.

1. The top line ***"Time Until Clear Air"*** annotates the number of minutes left before category 0 or category 2 will be ***assigned***, and the VCP can be changed to clear air mode (VCP 31 or 32). If category 1 is detected, this time will reset to 60 minutes.

2. The middle section has additional information on the detected and assigned category, and the time of category detection

3. The bottom section displays the threshold information pertaining to the category currently being ***detected***. The detected area can be compared to the threshold area to determine an appropriate setting for the nominal clutter area. Note that the detected category may not be the same as the assigned precipitation category found in the top section.

Selecting the proper setting for Nominal Clutter Area

The Precipitation Detection Status Screen can be used to determine the appropriate settings for the Nominal Clutter Area (NCA). The detected area

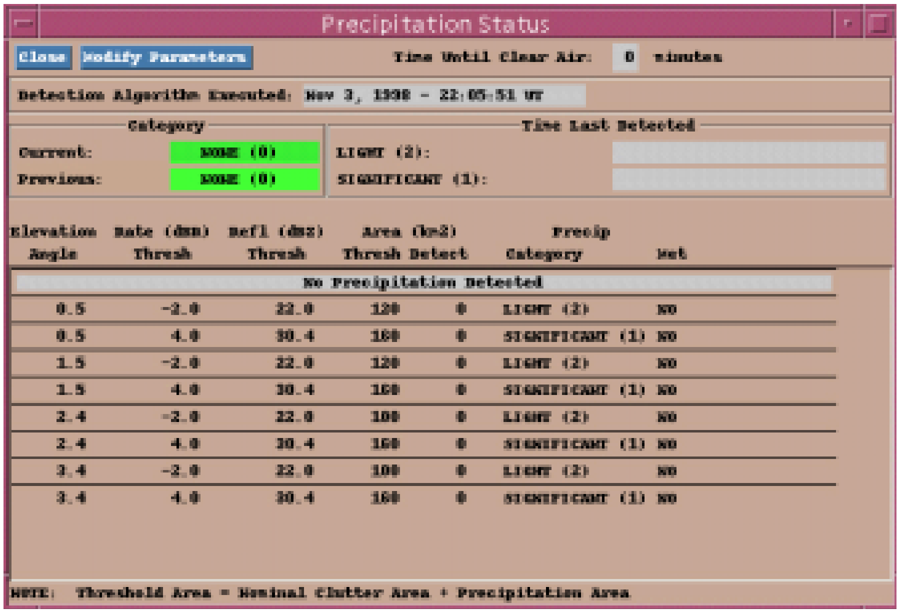


Figure 5-3. Precipitation Status Screen at the OPRG HCI.

gives you areal coverage of returns above the Precipitation Rate Threshold. In cases where the detected area returns are due strictly to residual clutter, a setting of the NCA slightly above the detected area will account for this residual clutter. By doing this on several “typical” days at an office, a “typical” setting for the NCA can be determined.

Complete run of Precipitation Processing Algorithms

The Precipitation Detection Function initiates the Precipitation Processing Subsystem (PPS), consisting of four algorithms which contain numerous quality control steps. Since radar only indirectly measures precipitation rates, extensive quality control is applied to get the best possible rainfall estimates. The four algorithms are:

1. Precipitation Preprocessing Algorithm

2. Precipitation Rate Algorithm

3. Precipitation Accumulation Algorithm

4. Precipitation Adjustment Algorithm

Because of the quality control steps used in these algorithms, the operator will notice a difference between the reflectivity data used as input and the corresponding precipitation products.

The PPS provides rainfall estimates out to 124 nm. No estimates are generated beyond 124 nm because errors increase rapidly beyond that range.

The algorithms in the PPS are highly flexible with many adaptable parameters. The process of tailoring adaptable parameters for each radar site requires research and observations from the field users of the system. Changes in adaptable parameter settings for a particular office requires coordination with the ROC and the Office of Hydrology.

Precipitation Preprocessing Algorithm

The Precipitation Preprocessing Algorithm uses base reflectivity from the four lowest elevation angles as input (regardless of VCP). This algorithm begins to execute at the end of the fourth elevation scan. The output of this algorithm is the Hybrid Scan Reflectivity and Digital Hybrid Scan Reflectivity (used to convert to rainfall rate).

Several quality control checks are made on the base reflectivity data to get the best reflectivity values to convert to rainfall rate.

Base Reflectivity Data Quality Control

Corrections to the data are made to compensate for:

1. Ground returns due to anomalous propagation

2. Spurious noise

3. Reflectivity outliers

4. Blockage by terrain

Ground Returns Due to Anomalous Propagation

Although Clutter Suppression is applied at the RDA, the Preprocessing Algorithm attempts to prevent residual clutter from being converted to precipitation. This step does ***not*** selectively remove clutter returns. It will either ***retain*** the reflectivity from the 0.5° elevation for precipitation processing or it will ***remove*** it.

The algorithm checks each volume scan to determine if a given percentage of echo areal coverage disappears from the lowest elevation angle to the next highest elevation angle. Currently, the percent reduction is set at 75%, but is adaptable. It may be set at a value between 25% and 100% with ROC approval. If 75% or more of the echo disappears from the lowest elevation angle to the next highest, the return from the lowest elevation angle is not considered to be precipitation and is no longer used in precipitation processing. This is called the ***"Tilt Test"***.

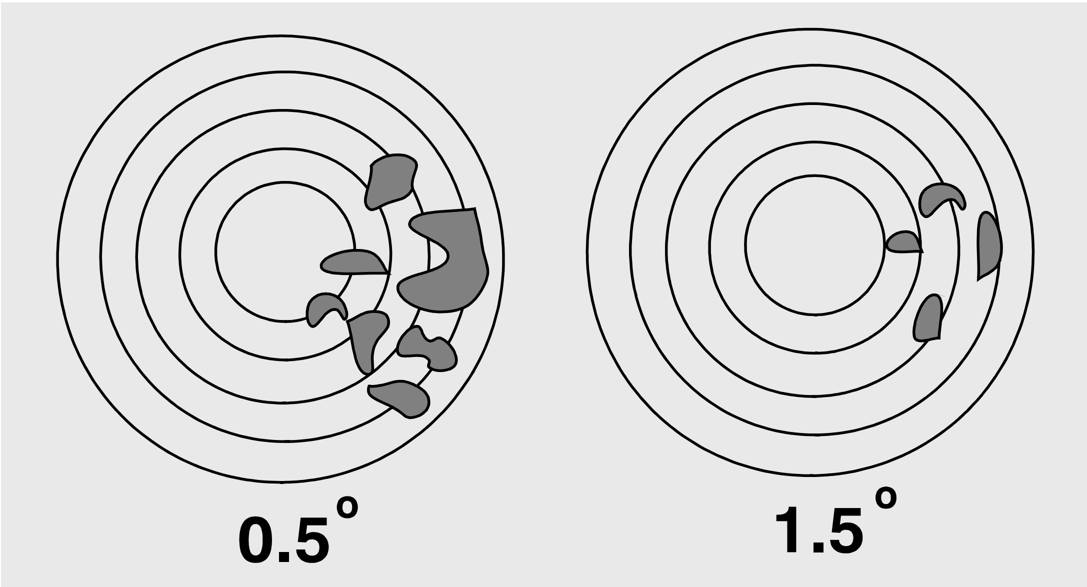


Figure 5-4. Tilt Test

Spurious Noise and Outliers

The Preprocessing Algorithm also attempts to correct for unrealistically high reflectivity values. caused by system noise or isolated targets such as airplanes, or by contamination from hail. These reflectivities are of two types, isolated reflectivities and reflectivity outliers.

Isolated Reflectivities

An isolated reflectivity is a value that indicates precipitation, but the range bin is in an area of non-precipitated returns. This may be caused by spurious noise or an airplane flying through the beam.

Reflectivity Outliers

An outlier is defined as a range bin which contains a dBZ value within an area of precipitable returns that is greater than is reasonably expected to occur. A range bin is flagged as an outlier if its reflectivity value exceeds the current outlier threshold (65 dBZ).

Blockage by Terrain

The Preprocessing Algorithm uses a “Terrain-Based Hybrid Scan” to select only those range gates of reflectivity that do not include terrain. Additionally, 1dBZ to 4dBZ are added to range bins behind partially blocked beams.

Terrain-Based Hybrid Scan

The Terrain-Based Hybrid Scan utilizes the reflectivity data from the four lowest elevation scans. The lowest elevation angle is used wherever the bottom of the beam clears the terrain by 500 ft. (done for each range bin along every radial). See Fig. 5-5. Note that when the Tilt Test discards the 0.5° slice, the 1.5° slice will be the lowest available elevation.

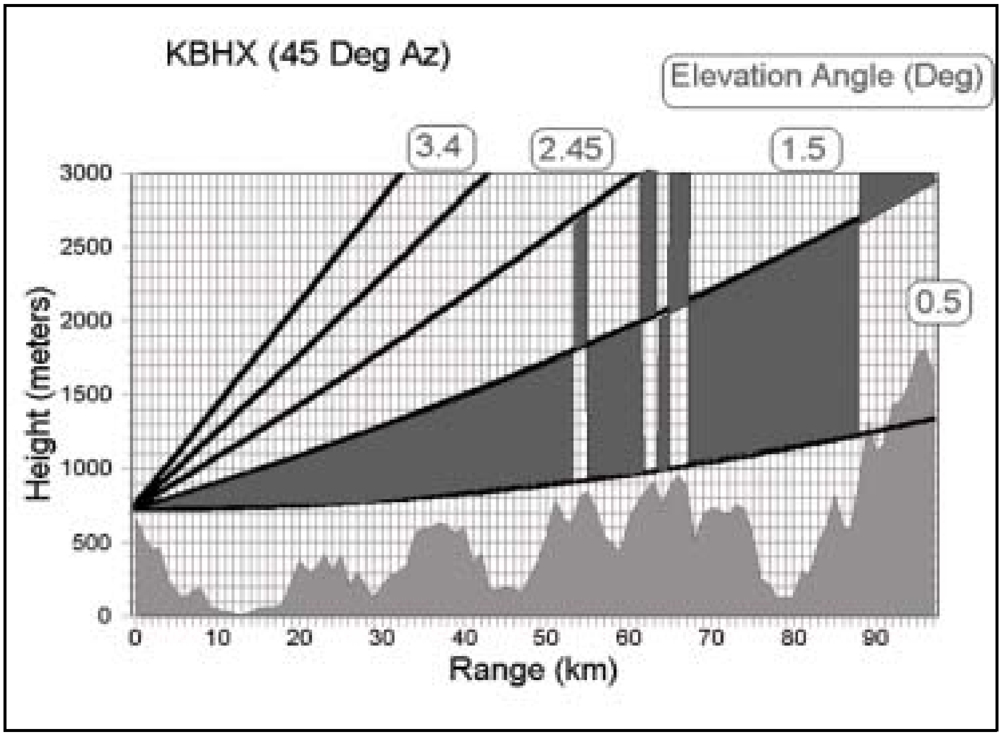


Figure 5-5. Terrain-Based Hybrid Scan Construction

Radials with Blockage

For radials with blockage of no more than 60%, 1dBZ to 4dBZs are added to the range bins beyond the obstacle (dependent on percentage of blockage.**(**See Fig. 5-6**)**

If more than 60% of the beam is blocked then one of two actions is taken. If the blockage is 2° or less in azimuth, the average value of the range bins next to the blockage, at that elevation angle, is assigned to the blocked range bins. If the blockage

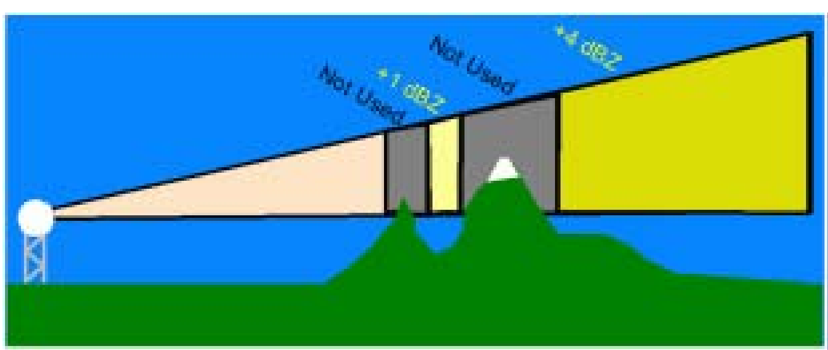


Figure 5-6. Radar Beam Blockage

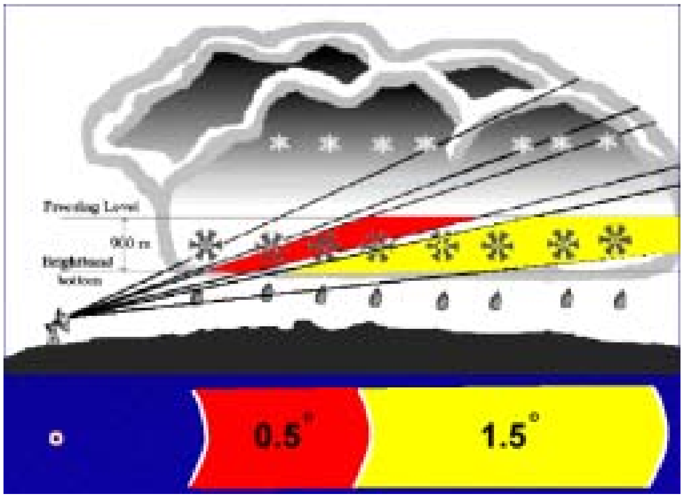


Figure 5-7. Bi-Scan Maximization and the Bright Band

is greater than 2° in azimuth, then no correction is made. For that sector, values from the next highest elevation angle would be used.

Bi-Scan Maximization

Bi-Scan Maximization chooses the greater reflectivity of the lowest 2 elevation angles at ranges defined at the RPG HCI. Bi-Scan Maximization is intended to help reduce the effects of beam losses at far ranges. Note that if 0.5° was discarded by the tilt test, then ***only*** 1.5° is available.

The Bi-Scan Maximization procedure can cause overestimation of precipitation amounts due to bright band or virga (see Fig. 5-8). This can be minimized by setting the *Min Range of Bi-Scan Maximization* to 230km (identical to the *Max Range of Bi-Scan Maximization*. This would in effect turn off the Bi-Scan Maximization part of the algorithm (see Fig. 5-8).

Results of Preprocessing Algorithm

The output from the quality control steps of the Preprocessing Algorithm is the 1° x 0.54 nm hybrid scan, which selects the best available estimate of low level reflectivity for conversion to rainfall rate. In addition to the remaining precipitation algo-

Name	Value	Range
Min Threshold dBZ for Isolated Bin Test [MNRFL]	18.0	-30.0 <= X <= 30.0, increments of 0.5 dBZ
Max dBZ Allowed Before Being Labelled as Outlier [MXRFL]	70.0	50.0 <= X <= 70.0, increments of 0.5 dBZ
Tilt-Test Low Reflectivity (dBZ) Value [RFTLT]	1.0	0.0 <= X <= 20.0, dBZ
Inner Range Limit for Tilt Test [IRTLT]	40	0 <= X <= 150, km
Outer Range Limit for Tilt Test [ORTLT]	150	40 <= X <= 230, km
Min Range of Bi-Scan Maximization [MNRBI]	180	0 <= X <= 230, km
Max Range of Bi-Scan Maximization [MXRBI]	230	0 <= X <= 230, km
Min Precip Area Echo Needed for Tilt Test in Low Elev [MNRCH]	600	100 <= X <= 3000, km**2
Min Area-Wgtd-Reflect Needed for Tilt Test in Low Elev [MNPAA]	10.0	0.0 <= X <= 20.0, dBZ
Max % Area Reduction Between 2 Lowest Elevations [MXPCT]	75	0 <= X <= 100, %
Min dBZ for Converting to Precip Rate (via table lookup) [MNDBZ]	0.0	-32.0 <= X <= 20.0, dBZ
Max dBZ for Converting to Precip Rate (via table lookup) [MXDBZ]	70.0	50.0 <= X <= 90.0, dBZ

Figure 5-8. Precipitation Preprocessing Algorithm adaptable parameters edit screen at RPG HCI

rithms, the hybrid scan is the input for the generation of the Radar Coded Message.

Interim Summary

Input to Precipitation Processing

Digitized Base Reflectivity Data from the four lowest elevation angles are transmitted to the RPG for processing.

Precipitation Detection Function

The Precipitation Detection Function (PDF) determines if precipitation is occurring within 124 nm of the radar and assigns a precipitation category each volume scan (Category 0 - No precipitation Category 1 - Precipitation, Category 2 - Light precipitation). If in Clear Air Mode (VCP 31 or 32), assignment of Category 1 automatically switches radar to VCP 21.

Preprocessing Algorithm

The Preprocessing Algorithm performs quality control steps (tilt test, spurious noise, reflectivity outliers and terrain blockage), resulting in the construction of the Hybrid Scan.

Hybrid Scan Reflectivity (HSR)

HSR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: 4 bit Hyb Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

HSR product annotations:

- VCP: 11, 21, 31 or 32

Additional HSR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 0.54nm X 1 degree
- DATA LEVELS: 16 data levels from +5 dBZ to + 75 dBZ.

Available every volume scan

A 16 data level reflectivity product from the four lowest elevation angles of base reflectivity.

Note: Do not confuse the HSR product with the Digital Hybrid Scan Reflectivity (DHR).

Hybrid Scan Reflectivity Applications

1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.

Hybrid Scan Reflectivity Limitations

1. Tilt test may eliminate valid returns at 0.5°.
2. Bi-Scan Maximization may increase negative impact of bright band contamination.

Digital Hybrid Scan Reflectivity (DHR)

DHR product legend description:

- RPG ID: kxxx
- PRODUCT NAME: Hybrid Scan Refl
- UNITS: (dBZ)
- DATE: Day of week, time, and date **in UTC**

DHR product annotations:

- VCP: 11, 21, 31 or 32

Additional DHR product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- DATA LEVELS: 256 data levels from -28 dBZ to + 90 dBZ. (0.5 dBZ increments)

Figure 5-9. Hybrid Scan Reflectivity

Available every volume scan.

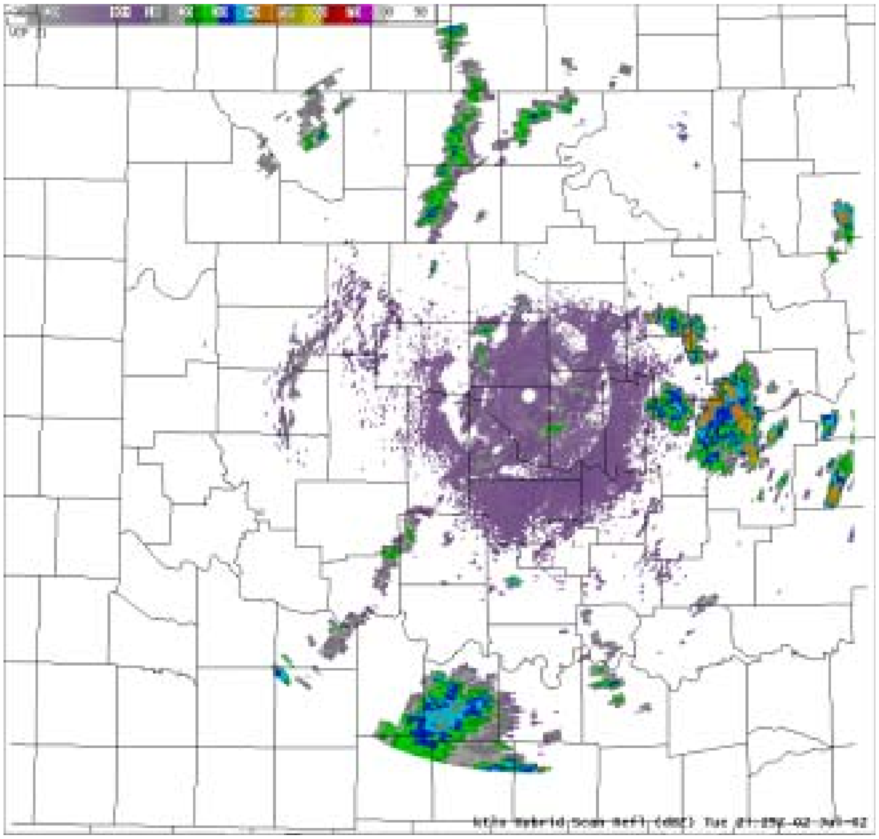


Figure 5-10. Digital Hybrid Scan Reflectivity (DHR)

Displays reflectivity data (from the four lowest elevation angles) used to produce the precipitation products.

DHR Applications

1. High resolution (256 data levels) allows for innovative color tables.
2. High accuracy (0.5 dBZ).
3. Used in the generation of external products.
   - Flash Flood Monitoring and Prediction (FFMP)
   - Jendrowski Scripts (Multiple Z/R AWIPS App)
   - Areal Mean Basin Estimated Rainfall (AMBER)

DHR Limitation

1. Large product size

Precipitation Rate Algorithm

The input to the Precipitation Rate algorithm is the best possible low level reflectivity value at each 0.54 nm x 1° range bin that was created by the Preprocessing Algorithm (Hybrid Scan). The reflectivity data (dBZ) are converted to rainfall rates (dBR, decibels of R, dBR=10 log R) using a Z-R relationship. The Rate Algorithm then performs a resolution change.

Converts 0.54 nm x 1° rate data to 1.1 nm x 1°

The rainfall rates at the 0.54 nm x 1°resolution are converted to a new resolution, 1.1 nm x 1°. This is done by averaging the rates in two adjacent 0.54 nm range bins, and placing the average in the corresponding 1.1 nm bin.

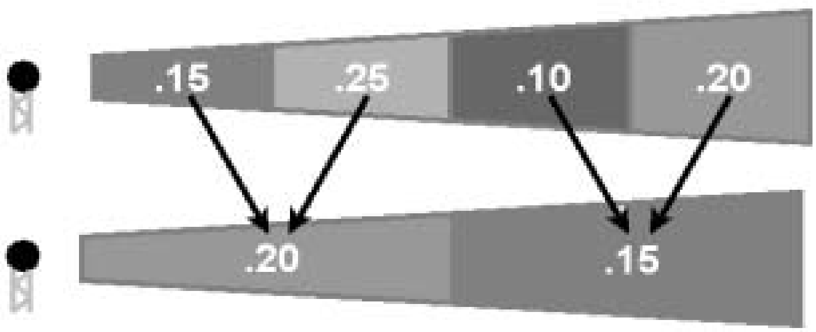


Figure 5-11. Rate Algorithm resolution conversion process

Maximum Precipitation Rate Allowed

The parameter *Maximum Precipitation Rate Allowed* should correspond to the Z/R relationship used. The default setting is 103.8 mm/hr, which equates to 4.09 in/hr (see Fig. 5-8). This value corresponds to the default Z/R relationship ($300R^{1.4}$). If the Z/R relationship is changed, a corresponding change to the *Max Precipitation Rate* should also be made.

Maximum Precipitation Rate Allowed Implications

Currently, a tropical and three stratiform specific Z/R relationships that can be invoked at the RPG HCI. With any of these Z/R relationships invoked and *Maximum Precipitation Rate Allowed* left at its default setting, rainfall rates would still be capped at 4.09 in/hr. This could cause significant underestimation using the tropical Z/R relationship ($250R^{1.2}$). When using the tropical Z/R, the *Max Precipitation Rate* should be changed to 154.2 mm/hr, which equates to 6.00 in/hr. For more information on the various Z/R relationships review the Precipitation Estimation section of IC 5.3.

Precipitation Accumulation Algorithm

The Precipitation Accumulation algorithm takes the output from the Precipitation Rate algorithm (rainfall rates for each 1° X 1.1 nm bin) and produces scan to scan and hourly accumulations for each 1° X 1.1 nm range bin. The Precipitation Accumulation algorithm also checks for missing rate scans.

Scan-to-Scan Accumulations

The volume scan to volume scan accumulations are produced for the Storm Total Precipitation Product. The Storm Total will update each volume scan for the duration of category 1 or 2.

Hourly Accumulations

There are two types of hourly accumulations that generate products:

Figure 5-12. Hydromet Rate Algorithm adaptable parameters edit screen at RPG HCI.

1. One hour ending at the current volume scan

The first type of hourly accumulation is one hour ending at the current volume scan, and is used to produce the One Hour Product. The One Hour Product is a **moving** one hour window that is updated:

- every 5 or 6 minutes if in mode A
- every 10 minutes if in mode B

2. One hour ending at the top of each hour

The second type of hourly accumulation is one hour ending at the top of the hour. Two out of three top of the hour (or clock hour) accumulations are required to produce a Three Hour Product. This product is available each volume scan, but the accumulations are updated ***only*** at the top of each hour.

Example

Rain starts at 2:43 PM and stops at 4:30 PM.

The first nonzero accumulation would be one hour ending at 3:00 PM. The second nonzero accumulation would be one hour ending at 4:00 PM, and the third would be one hour ending at 5:00 PM.

The Three Hour Product would be available the first volume scan after 3:00 PM, since two top of the hour accumulations would be available:

- 1:00 - 2:00, zero accumulation
- 2:00 - 3:00, nonzero accumulation

The User Selectable Precipitation (USP) Product is also created using top of the hour accumulations. Two thirds of the requested time period must be available for product generation. Like the Three Hour Product, the USP is available each volume scan, but will only contain accumulations ending at the top of the clock hour.

Check for Missing Data

The Accumulation algorithm also checks for and attempts to correct for missing rate scans. As the time between scans increases, so also increases the error in the precipitation estimate. For example, an outage time of 10 minutes statistically results in 15% error, while an outage time of 15 minutes results in 25% error. In this setting, an outage is any type of failure that prevents base data from being received at the RPG.

Figure 5-13. Radar outage less than 30 minutes. No data are labeled missing.

In the Accumulation algorithm, if the time between consecutive scans is less than or equal to 30 minutes, the precipitation rates are averaged between the last good volume scan and the first good one. This average is then multiplied by the time between scans (outage time), to compute an accumulation. See Fig. 5-13.

If the time between consecutive volume scans is greater than 30 minutes, the Accumulation algorithm extrapolates the rate from the last good volume scan for an additional 15 minutes. The final 15 minutes of the outage is assigned the rate from the first good volume scan after the outage. The excess time between these two extrapolations is labeled missing. See Fig. 5-14.

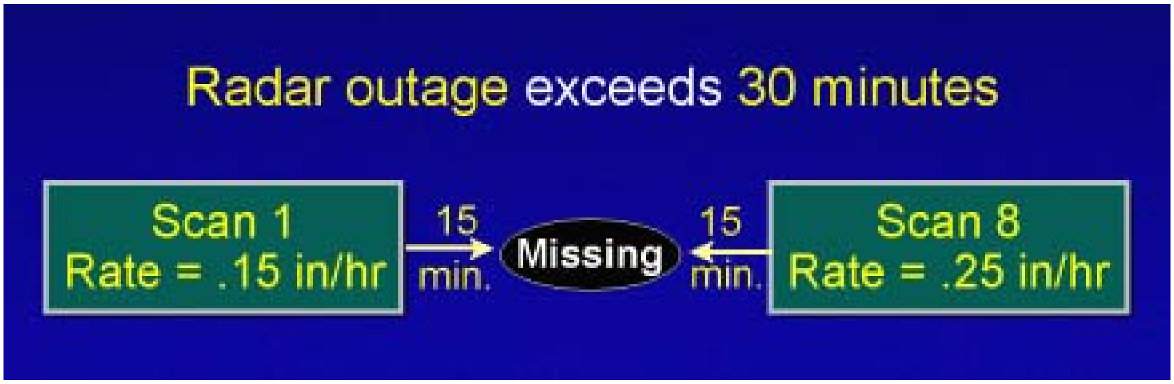


Figure 5-14. Radar outage longer than 30 minutes. Data beyond 30 minutes are labeled missing.

If missing data exceeds 6 minutes (radar outage exceeds 36 minutes), hourly accumulations are not computed.

1. One Hour Product not generated.
2. Three Hour Product not generated until 2 top of the hour accumulations (zero or nonzero) are available. This product may include missing data.
3. The User Selectable Precipitation Product is not generated unless 2/3 of the requested hourly accumulations are computed. When generated, the product may then contain periods of missing data. Missing data periods are listed on the USP attribute table.
4. Storm Total Product will be generated though data are missing.

In category 0, “zeros” are accumulated; a zero accumulation is ***not*** missing data.

Interim Summary

Hybrid Scan Reflectivity (HSR) Product

Hybrid Scan Reflectivity (HSR) is a **16** data level product depicting the reflectivity used for the precipitation products. The reflectivity depicted is output from the Preprocessing Algorithm, and has already undergone the quality control steps (tilt test, spurious noise, reflectivity outliers and terrain blockage).

Digital Hybrid Scan Reflectivity (DHR) Product

Digital Hybrid Scan Reflectivity (DHR) is a **256** data level product of the reflectivity used for the precipitation products.The reflectivity depicted is output from the Preprocessing Algorithm, and has already undergone the quality control steps (tilt test, spurious noise, reflectivity outliers and terrain blockage).

Rate Algorithm

The Rate Algorithm converts Reflectivity to Rainfall Rate and changes resolution from 0.54 nm x 1° to 1.1 nm x 1°

Accumulation Algorithm

The Accumulation Algorithm computes scan-to-scan and hourly accumulations and checks for missing periods of data.

Precipitation Adjustment Algorithm

As of AWIPS Build 5.2.2, a new attempt will be made to correct for two errors that have proven difficult:

1. Non-representative Z-R relationship
2. Incorrect hardware calibration

The WFO version of AWIPS Build 5.2.2 will generate Bias Tables using the AWIPS Multisensor Precipitation Estimator (MPE) function. These tables will be transmitted on a regular hourly basis (or more frequently at operator discretion) to the RPG associated with that WFO. The Bias Table reflects gage/radar differences over various time scales, and is input to the Precipitation Adjustment Algorithm at the RPG.

A Bias Flag (True/False) is set at the RPG to determine whether the multiplicative bias will be used or not. If the Bias Flag is set to True a multiplicative Bias will be made to the both the scan-to-scan and hourly accumulation over the entire 124 nm range.

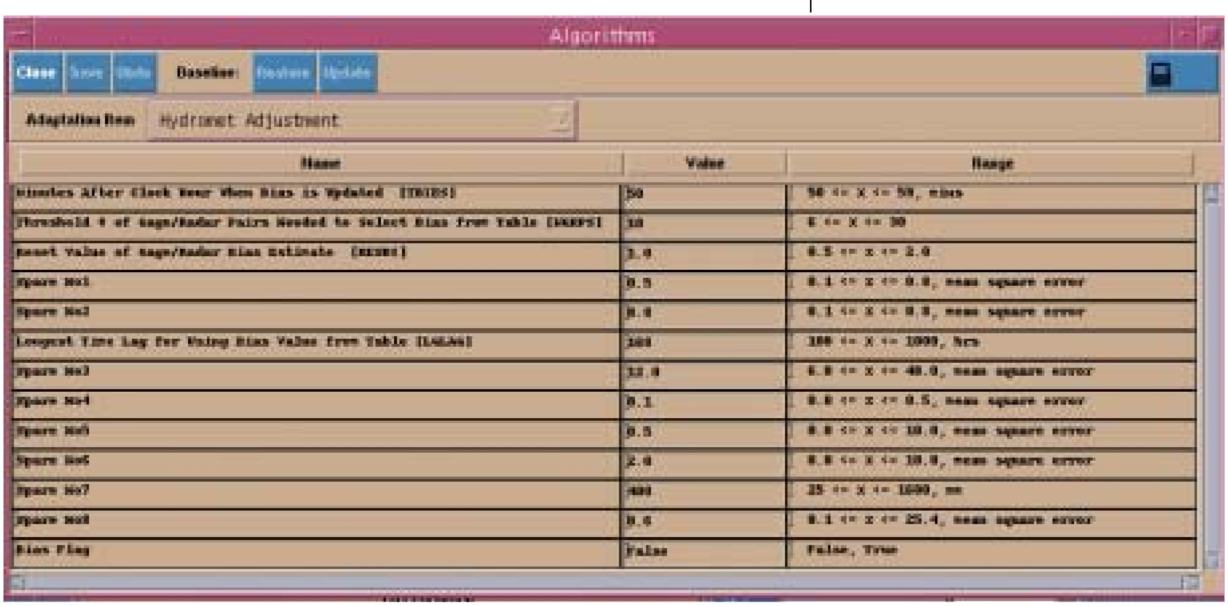


Figure 5-15. Hydromet Adjustment Algorithm adaptable parameters edit screen at RPG HCI.

Bias Effect on Products

When the Bias Flag is set to true, the bias is applied differently on the precipitation products.

- One Hour Precipitation (OHP) - Bias applied to entire hour of accumulation.
- Three Hour Precipitation (THP) and User Selectable Precipitation (USP) - Each top-of-the-hour's bias used.
- Storm Total Precipitation (STP) - Each volume scan bias used

A Word of Caution

The Bias Flag default is False. Caution should be used when setting the Bias Flag to True. The bias is available to correct for non-representative Z-R relationships or incorrect hardware calibrations. Bias values may be produced by other factors such as rain gage inaccuracies and below beam effects (strong winds, evaporation, or coalescence). Also the sampling area of a rain gage is considerably smaller than the radar range bin, especially at long ranges.

Precipitation Processing Subsystem - Strengths

Only source of real time high resolution rainfall accumulations.

Significant quality controls are designed to produce better products by:

1. minimizing overestimation due to ground return caused by anomalous propagation,
2. eliminating reflectivity outliers and spurious noise, and
3. reducing the effects of beam blockage.

Precipitation Processing Subsystem - Limitations

Algorithms do not account for:

1. below beam effects (wind, evaporation, coalescence),
2. non-uniform Z/R relationships within the radar coverage area.

Algorithms do not always account for:

1. bright band contamination,
2. hail contamination, and
3. inaccuracies due to radar outages.

Summary - Algorithm Section

The Precipitation Detection Function determines a precipitation category.

The Preprocessing Algorithm performs quality control steps and constructs the hybrid scan.

The Rate Algorithm converts Reflectivity to rainfall rate.

The Accumulation Algorithm computes scan-to-scan and hourly accumulations.

The Adjustment Algorithm applies a multiplicative bias computed at AWIPS using rain gage to radar comparisons.

Precipitation Products

- One Hour Precipitation (OHP)
- Three Hour Precipitation (THP)
- Storm Total Precipitation (STP)
- User Selectable Precipitation (USP)
- One Hour Digital Precipitation Array (DPA)
- Supplemental Precipitation Data (SPD)

One Hour Precipitation

OHP product legend description: (Fig. 5-16)

- RPG ID: kxxx
- PRODUCT NAME: One Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

OHP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False. (AWIPS 5.2.2)
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional OHP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Displays accumulations for the past hour.

Available from the first volume scan with detected rainfall (category 1 or 2).

Updated every volume scan after the first product - a moving one hour window of precipitation.

Figure 5-16. One Hour Precipitation

One Hour Precipitation - Applications

1. Assess rainfall accumulations for flash flood watches, warnings, and statements
2. Nowcasts and special weather statements
3. Time lapse can provide storm movement
4. Other water management applications

One Hour Precipitation - Limitations

1. After extended outages, first product will not be generated for 54 minutes
2. For some events, viewing interval too short

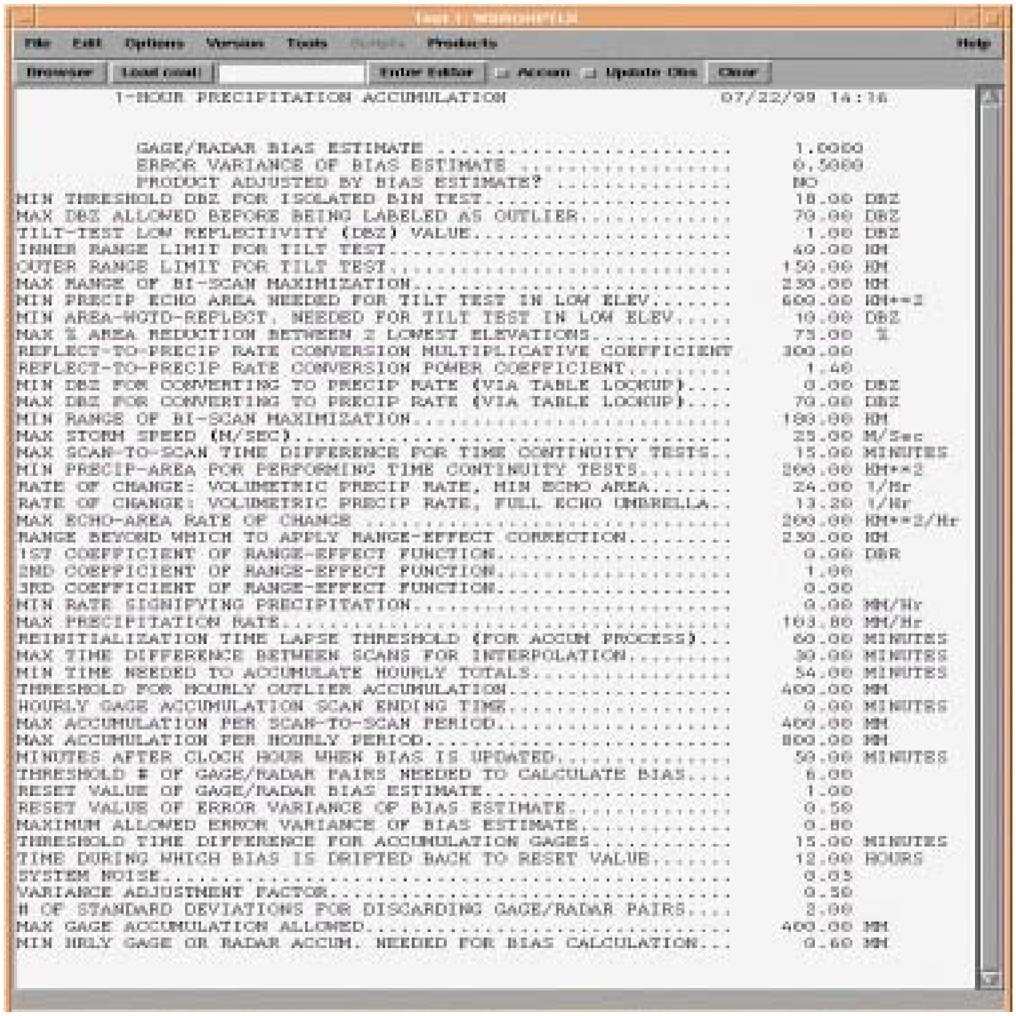


Figure 5-17. OHP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

Three Hour Precipitation

THP product legend description: (Fig. 5-18)

- RPG ID: kxxx
- PRODUCT NAME: Three Hour Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

THP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.

- BIAS/ERR: Each hours multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False (AWIPS 5.2.2).
- END: This is the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional THP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 12.70 inches in multiples of 0.05 inch. Data level values are selected at the RPG HCI, and are under URC change authority.

Product accumulations updated once per hour, at the top of the hour

Requires two out of past three top of the hour accumulations (zero or nonzero) for product generation

Not recommended for RPS list

Three Hour Precipitation - Applications

1. Provides a longer viewing interval
2. For very long duration events, can be used with Storm Total Product for analysis
3. Corresponds to timing of flash flood guidance values

Three Hour Precipitation - Limitations

1. Product updated only once per hour

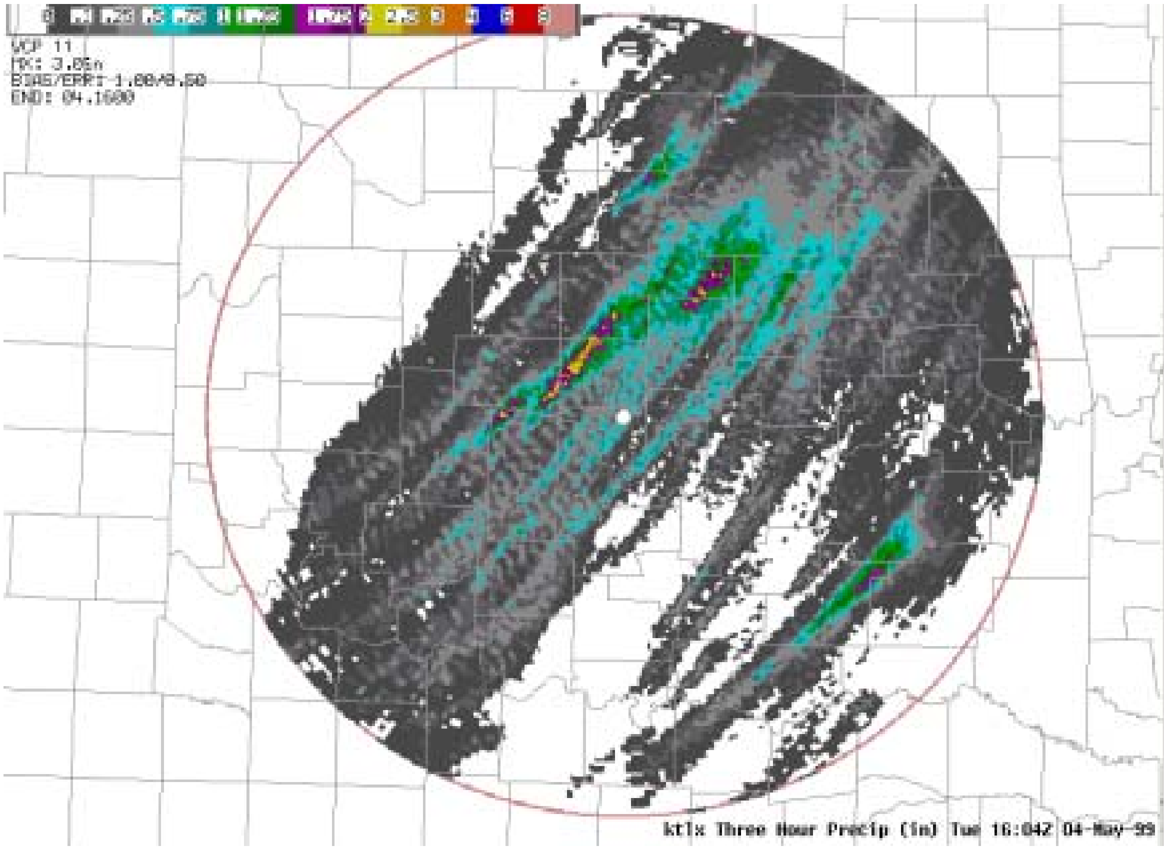
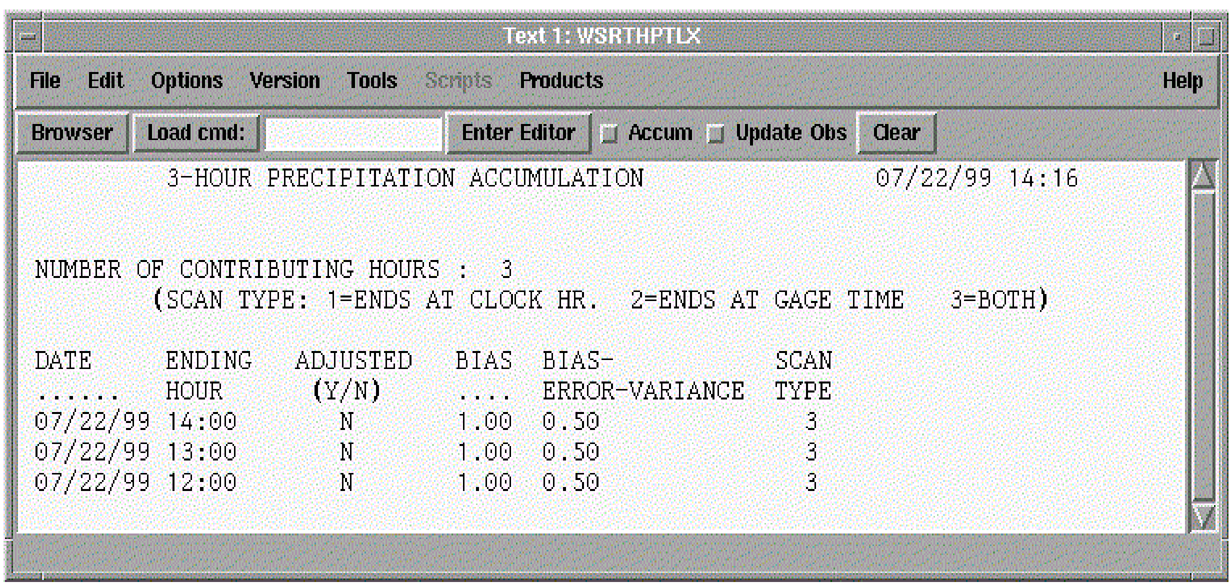


Figure 5-18. Three Hour Precipitation



3-HOUR PRECIPITATION ACCUMULATION 07/22/99 14:16

NUMBER OF CONTRIBUTING HOURS : 3
(SCAN TYPE: 1=ENDS AT CLOCK HR. 2=ENDS AT GAGE TIME 3=BOTH)

DATE	ENDING	ADJUSTED	BIAS	BIAS-	SCAN
......	HOUR	(Y/N)	....	ERROR-VARIANCE	TYPE
07/22/99	14:00	N	1.00	0.50	3
07/22/99	13:00	N	1.00	0.50	3
07/22/99	12:00	N	1.00	0.50	3

Figure 5-19. THP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

Storm Total Precipitation

STP product legend description: (Fig. 5-20)

- RPG ID: kxxx
- PRODUCT NAME: Storm Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

STP product annotations:

- VCP: 11, 21, 31 or 32
- MX: This is the maximum accumulation of precipitation on the product. The location of this value is unknown.
- BIAS/ERR: The most recent multiplicative bias is displayed whether or not the Bias Flag at the RPG is set to True or False (AWIPS 5.2.2).
- BEG: Date/time of the first volume scan where category 1 or 2 was assigned.
- END: This the date/time for the accumulations computed by the PPS for the particular volume scan.

Additional STP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, with a range of 0.00 to 25.4 inches in multiples of 0.1 inch. Data level values selected at the RPG HCI (URC change authority).

Displays total rainfall accumulation

Available from the first volume scan with detected rainfall (category 1 or 2)

Updated every volume scan as long as the system remains in category 1 or 2

Accumulations reset to zero after one hour of no precipitation (category 0).

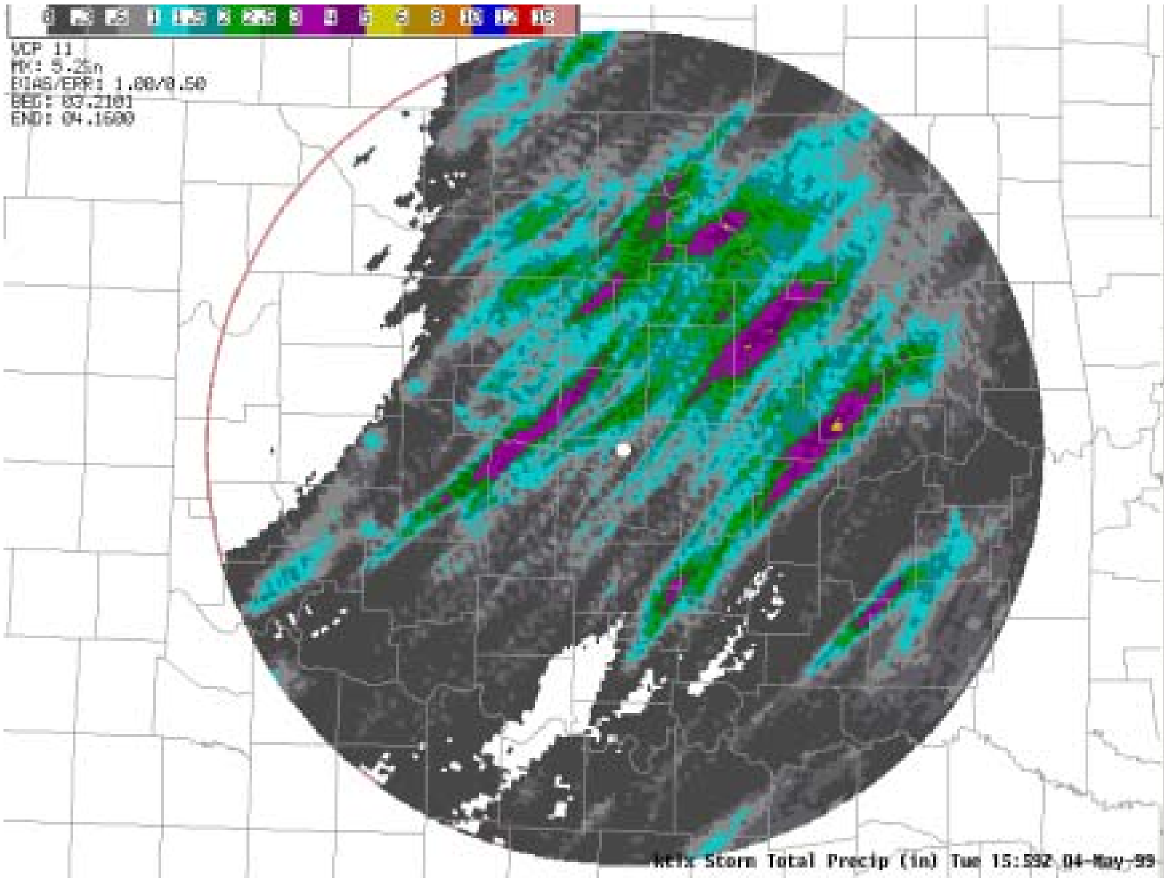


Figure 5-20. Storm Total Precipitation

Storm Total Precipitation - Applications

1. Monitor total precipitation accumulation
2. Estimate ground saturation and/or total basin runoff
3. Post storm analysis
4. Time lapse for tracking motion of storms

Storm Total Precipitation - Limitations

1. Can stay in category 1 or 2 for extended periods of time - can not manually reset to zero.

2. Could include missing data without the knowledge of the operator.

Figure 5-21. STP Alphanumeric Product (AWIPS Version 5.2.1 will change in AWIPS version 5.2.2)

User Selectable Precipitation

USP product legend description: (Fig. 5-22)

- RPG ID: kxxx
- PRODUCT NAME: User Def Total Precip
- UNITS: (in)
- DATE: Day of week, time, and date **in UTC**

USP product annotations:

- VCP: 11, 21, 31 or 32

Additional USP product characteristics:

- SCALE: WFO Scale
- RANGE: 124 nm
- RESOLUTION: 1.1nm x 1 degree
- DATA LEVELS: 16 data levels available, OHP/THP data levels or STP data levels used

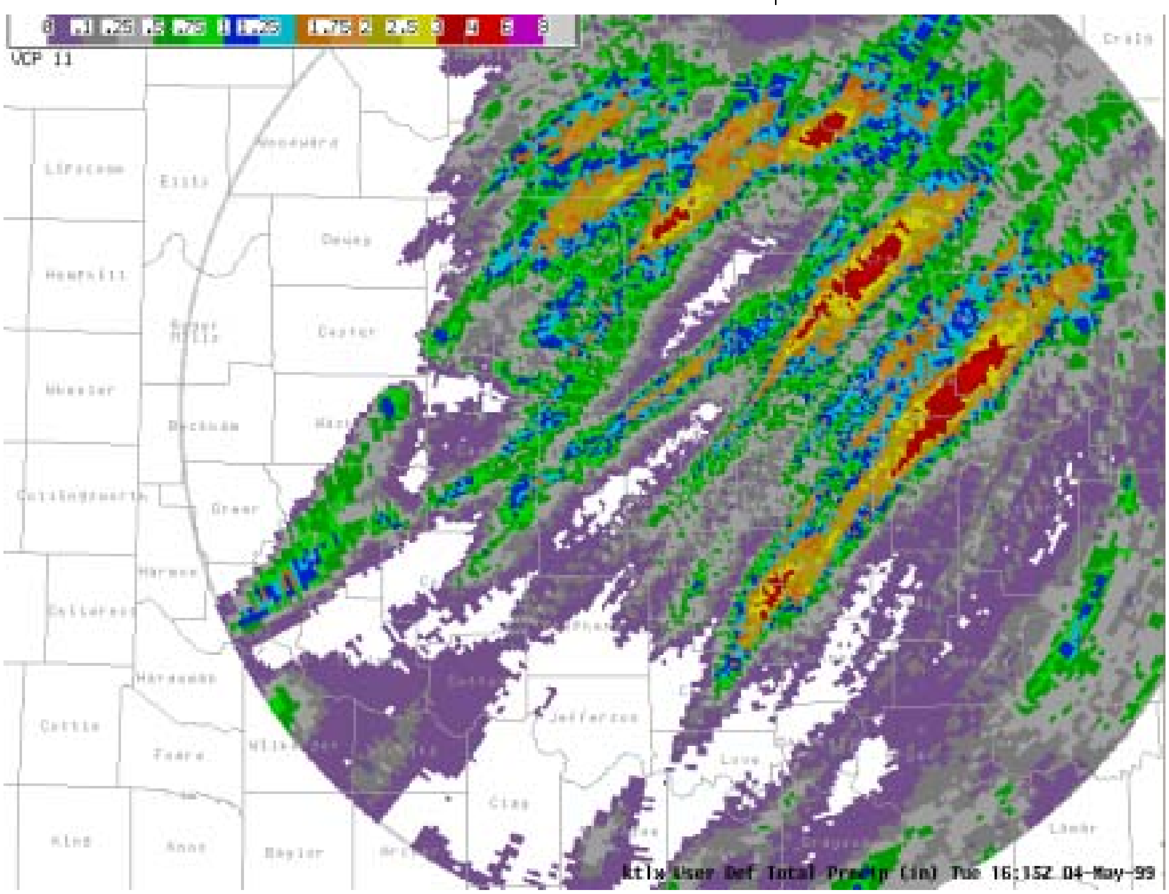


Figure 5-22. User Selectable Precipitation

dependent on the magnitude of accumulations Displays precipitation accumulations for a user specified period of time using top of the hour accumulations. The past 30 hours of top of the hour accumulations are available.

User selects duration (up to 24 hours) and end time

- Default USP generated for 24 hours ending at 12Z.

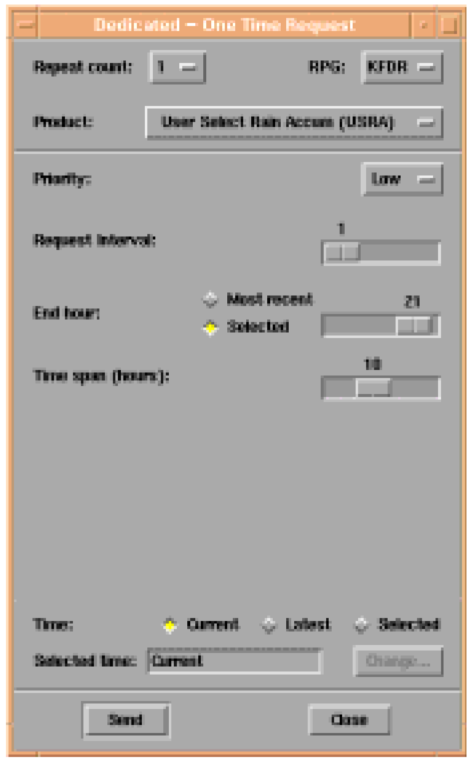


Figure 5-23. One Time Request

User Selectable Precipitation - Applications

1. Flexible time interval to meet varying weather situations
2. In addition to the 24 hour default USP, any others generated for dedicated users are available by OTR to dial-up users.

User Selectable Precipitation - Limitations

1. USP accumulations are updated only at the top of the hour

2. Product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.
3. Since the USP is a customized product, only 10 can be generated per volume scan.

One Hour Digital Precipitation Array (DPA)

The RPG produces another hourly product, called the One Hour Digital Precipitation Array (DPA). Instead of the 1.1 nm x 1° polar grid, the DPA has a rectangular grid of about 2.2 x 2.2 nm. Instead of 16 data levels, the DPA has 256 data levels. Similar to the One Hour Precipitation Product, the DPA has a moving one hour of accumulation (scan-to-scan accumulations). The product is used by the RFCs to generate precipitation input for the NWS River Forecast System (NWSRFS), and the AWIPS Multisensor Precipitation Estimator (MPE) used for the bias calculation. The rectangular grid allows for mosaicking the numerous WSR-88Ds within the RFC's area of responsibility.

Supplemental Precipitation Data (SPD)

The Supplemental Precipitation Data is an **alpha-numeric only** product received at the AWIPS workstation like any other product. (Fig. 5-24)

Output on PPS algorithms (each volume scan):

1. current bias value
2. information on gage-radar pairs
3. number of isolated bins and outliers that are corrected
4. percent echo reduction from 0.5° to 1.5° from the tilt test
5. ratio of range bins chosen from the 1.5° vs 0.5° slices from bi-scan maximization periods of missing data

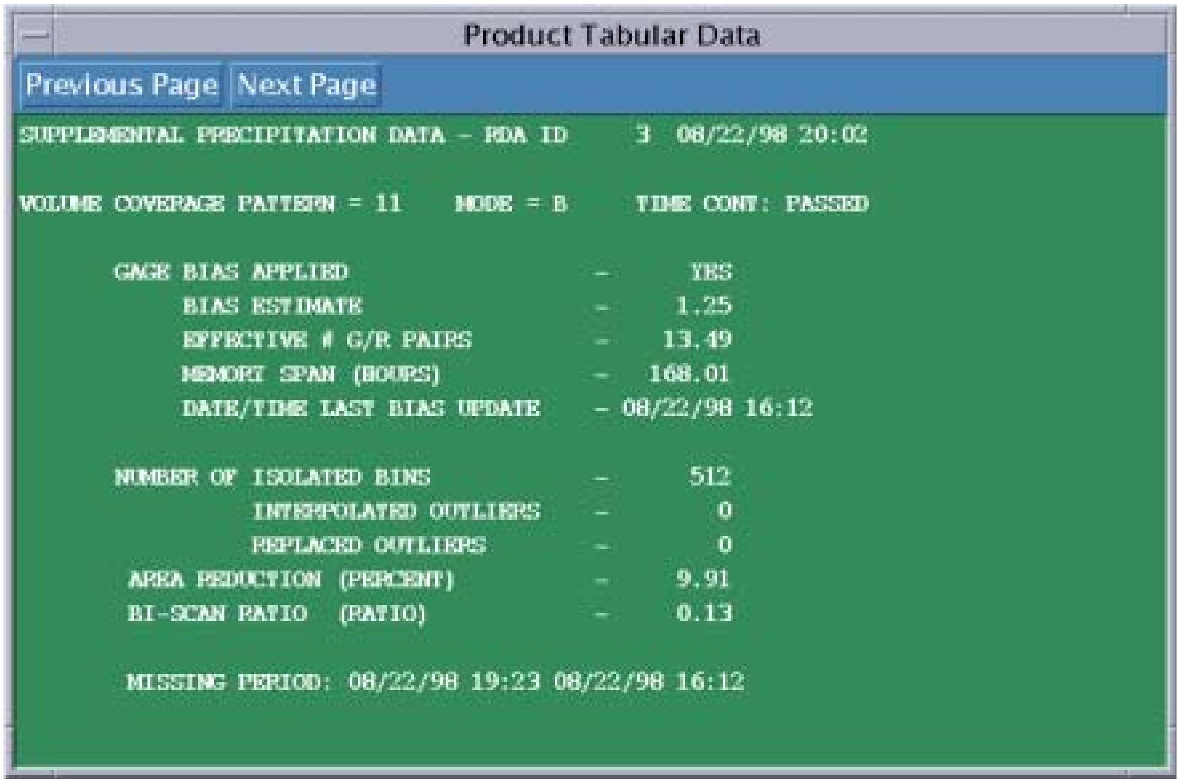


Figure 5-24. Supplemental Precipitation Data (AWIPS 5.2.2 Version)

Precipitation Data Levels

Introduction

Data levels on the One Hour, Three Hour, and Storm Total Precipitation products may be edited at the RPG HCI in accordance with policies set forth by your local Unit Radar Committee.

Why modify Precipitation Data Levels?

Data level changes depend on the location of the radar, topography and previous weather in the area of concern. For example, data levels in parts of the Western states may need more detail in the lower end of the scale than areas of the Gulf Coast states.

One/Three Hour Precipitation Products

The One/Three Hour Precipitation product has 16 accumulation data levels corresponding to each of the 16 color codes represented on the product.

The first data level is non-modifiable and has the acronym ND (No Data) for areas with no accumulation or areas outside the product coverage area.

The second data level is also non-modifiable and is given a value of > 0.00. This is color code 2 and displays regions with accumulations greater than zero but less than the level set for code 3.

The remaining levels, codes 3 to 16, are modifiable by the operator and range from 0.05 through 12.70 inches in multiples of 0.05 inch.

Storm Total Precipitation Product

The Storm Total Precipitation product also has 16 data levels and is modified the same as the One/Three Hour product. The only difference is the range of the data levels.

Once again levels 1 and 2 are non-modifiable. Levels 3 to 16 are modifiable and range from 0.1 through 25.4 inches in multiples of 0.1 inch.

Editing OHP/THP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters - OHP/THP Data Levels (See Fig. 5-25.)

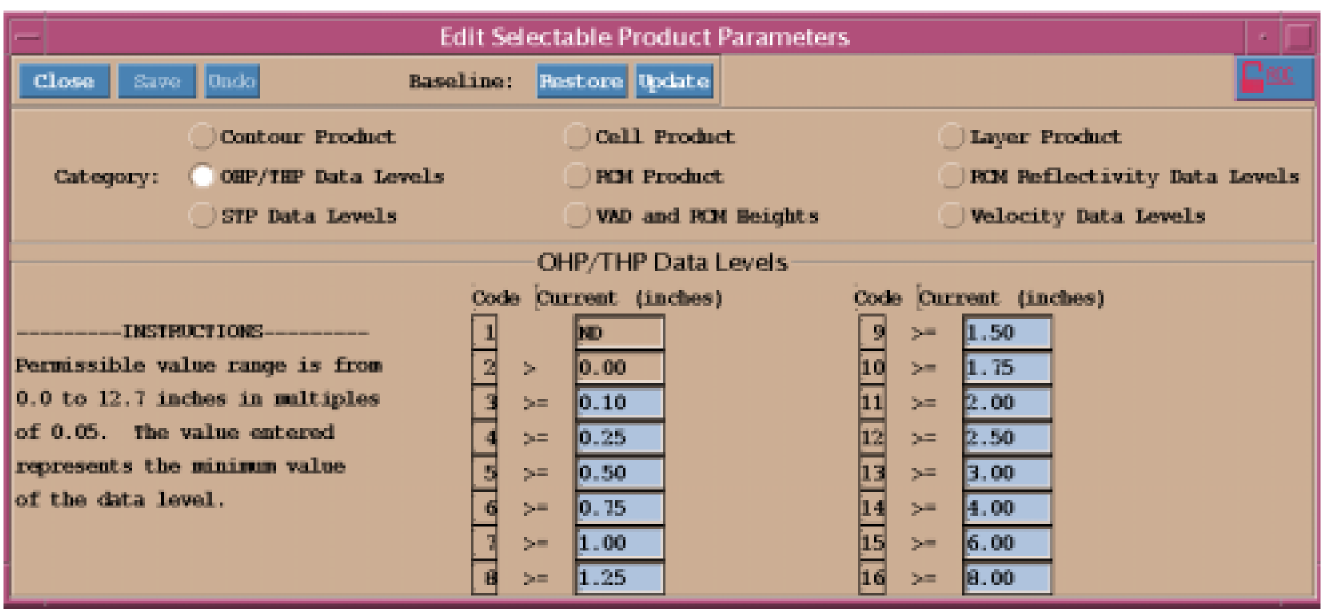


Figure 5-25. Edit screen for the OHP/THP product data levels at the RPG HCI.

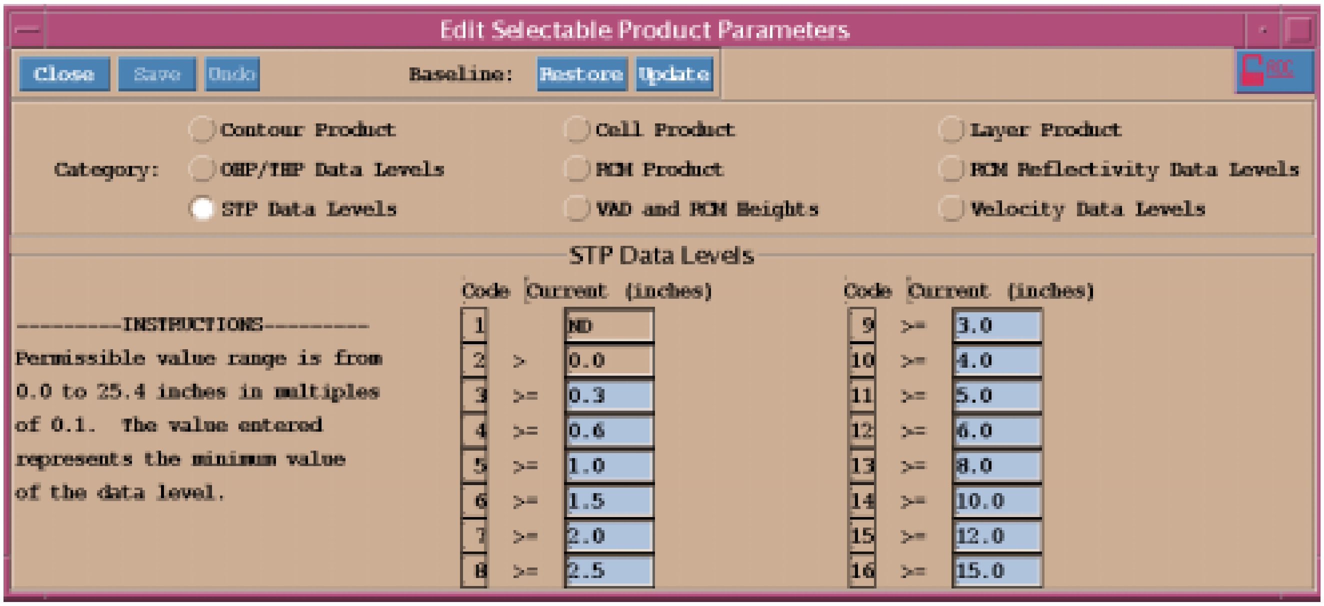


Figure 5-26. Edit screen for the Storm Total Precipitation product data levels on the RPG HCI.

Editing STP Data Levels at RPG HCI

Click on User - Products - Selectable Parameters STP Data Levels (See Fig. 5-26.).

Summary - Precipitation Products

Graphical and/or Alphanumeric Products at the AWIPS Workstation

1. Hybrid Scan Reflectivity (HSR)
2. Digital Hybrid Scan Reflectivity (DHR)
3. One Hour Precipitation (OHP)
4. Three Hour Precipitation (THP)
5. Storm Total Precipitation (STP)
6. User Selectable Precipitation (USP)
7. Digital Precipitation Array (DPA)
8. Supplemental Precipitation Data (SPD

8/03

Worksheet

Storm Cell Algorithms and Products

The following pertain to the SCIT algorithm and products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?

2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?

3. a. What environmental data must be set for the Hail Detection Algorithm to be representative?

   b. How often should this information be updated?

   c. Whose responsibility is it to do so?

4. What radar limitations must be kept in mind when interpreting the table information seen in SCAN?

5. Where can you adjust the number of storms to be displayed from the Storm Track Product?

6. The cell-based VIL of a storm as seen on a SCAN trend window appears to be diminishing as the storm approaches the radar. What non-meteorological reason could there be to explain this display?

Worksheet
Storm Cell Algorithms and Products....ANSWERS!!

1. Which VCP will generally give more representative output of derived products, especially within 60nm of the radar?

   VCP 11 - Less gaps

2. Who has the authority to make changes to the 7 reflectivity thresholds used to identify storm cells in the SCIT algorithms?

   ROC

3. a. What environmental data must be set for the Hail Detection Algorithm to be representative?
      Heights of the 0 degree and -20 degree isotherms.

   b. How often should this information be updated?
      At least twice a day, or as often as necessary to reflect environmental conditions.

   c. Whose responsibility is it to do so?
      The local office with RPG HCI control.

4. What radar limitations must be kept in mind when interpreting the table information seen in SCAN?
   These would include radar horizon effects, scan strategy, and aspect ration. Althought these sampling considerations affect base data as well as algorithm output, the impacts may be tougher to remember and quantify with algorithm output.

5. Where can you adjust the number of storms to be displayed from the Storm Track Product?
   These values, as well as those impacting output from the Hail Algorithm, TVS display, MRU display and SRM default motion can be found via the Icon Graphic Controls in the "Radar" menu on AWIPS.

6. The cell-based VIL of a storm as seen on a SCAN trend window appears to be diminishing as the storm approaches the radar. What non-meteorological reason could there be to explain this display?
   The storm with which the VIL is associated is probably being impacted by the cone of silence as it gets closer to the radar. This means less and less of the storm is being sampled. All cell-based attributes, not just cell-based VIL, will be impacted by this.

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Review Exercises
SCIT Products and Displays

Instructions: Select the most correct answer.

1. Which of the following statements about the Storm Track Information Product is **true**?

   a) Right turning storms will be indicated by a curved forecast track.
   b) Past positions will be plotted in volume scan intervals.
   c) The movement of hurricanes will be well tracked.

2. Which of the following statements is **true** about the Storm Track Information Product?

   a) The product can only be used as an overlay on volume products.
   b) Lines of storms will usually treated as a single cell.
   c) Storm cells in close proximity to one another may have erroneous attributes.

3. True/False The Hail product no longer takes into account the environment.

4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?

   a) Overestimate the actual hail size.
   b) Underestimate the actual hail size.
   c) Have no effect on the estimated hail size.

Question 5 will use the Trend Display from the SCAN table (Figure 1)

5. What is the likely reason that the storm top appears to decrease at 0030 in the trend window on the left?

   a) The storm probably weakened for that one volume scan.
   b) The algorithm lost the storm entirely for that volume scan.
   c) The storm incorrectly had some of its components assigned to neighboring cells for that volume scan.

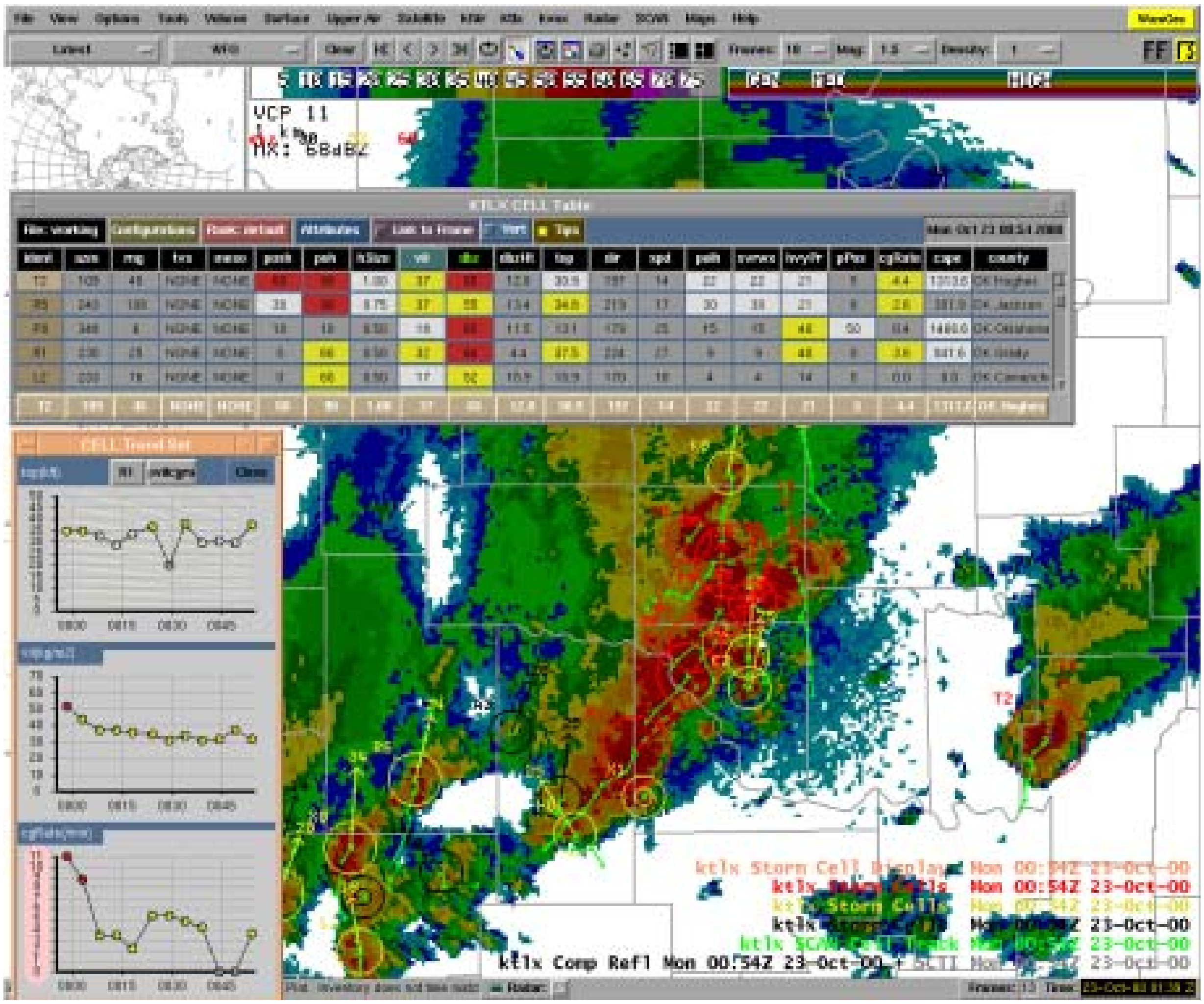


Figure 1. SCAN display which includes trend windows for Top, Cell-based VIL, and CG rate.

Review Exercises
SCIT Products and Displays
******ANSWERS******

Be sure and look at all answers if you are not sure why they are right or wrong.

1. Which of the following statements about the Storm Track Information Product is **true**?

   a) Right turning storms will be indicated by a curved forecast track.
   No. Forecast tracks will always be indicated with a straight line. If a storm's past track indicates it is turning, the user should mentally adjust the forecast positions to account for this.

   b) Past positions will be plotted in volume scan intervals.
   Yes. Up to 10 volume scans of past positions will be displayed. A storm whose centroid is deviating will have this represented in the past tracks.

   c) The movement of hurricanes will be well tracked
   While individual cells within the hurricane may be tracked pretty well, the overall movement of the hurricane will not be.

2. Which of the following statements is **true** about the Storm Track Information Product?

   a) The product can only be used as an overlay on volume products.
   No. Actually you can overlay the STI on any other geographic product (volume or base). The problem is that they must be from the same volume scan, i.e the times must match. This is why when you get a newly arriving Base Reflectivity, for example, and try to overlay the STI on it, it will not display (it has not been generated yet for that volume scan).

   b) Lines of storms will usually treated as a single cell.
   No. The SCIT algorithm will define areas of higher reflectivities within the line as individual cells. It will also usually break apart large core storms as they get closer to the RDA.

   c) Storm cells in close proximity to one another may have erroneous attributes..
   Yes! Because the SCIT algorithm tries to separate out individual cells in a cluster of cells, it will occasionally mismatch low and higher level components. For instance, a cell which previously was identified to 40Kft may have its top half assigned to a nearby cell in the next volume scan. Imagine what this would do to the Cell Trend information for both of these cells!

3. True/False The Hail product no longer takes into account the environment.

The answer is False! It does attempt to account for changes in the environment by using the height of the 0 degree and -20 degree isotherms (input at the ORPG HCI).

4. A forecast office observes thunderstorms ahead of a cold front in the warm sector, and other ones deep in the cold air behind the front. The Hail Temperatures Data was input during the morning before the front went through. What will the Hail Product likely do with the storms in the **cold sector**?

a) Overestimate the actual hail size.
No - just the opposite. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

b) Underestimate the actual hail size.
Yes! Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

c) Have no effect on the estimated hail size.
It will likely have an effect, which could be substantial depending on how drastic a change has taken place. Imagine the freezing level was at 12Kft in the morning, and is now down to 4Kft. The height of the -20 degree isotherm has also dropped a few thousand feet. The algorithm checks to see how far above the freezing level (and how far above the height of the -20 degree isotherm) the 40-50dBZ core is. It will obviously underestimate these depths if still using the higher altitudes from the morning sounding. This will lead to an underestimation of the hail size in this cold sector.

Question 5 will use the Trend Display from the SCAN table (Figure 1).

5. What is the likely reason that the storm top appears to decrease at 0030 in the trend window on the left?

a) The storm probably weakened for that one volume scan.
Possible but not likely. This is where you have to be careful in interpreting trends without supporting information. The fact that only one volume scan showed a dramatic drop is suspicious.

b) The algorithm lost the storm entirely for that volume scan.
No. If the algorithm had lost the storm entirely, it would have lost all attributes

in this volume scan.

c) The storm incorrectly had some of its components assigned to neighboring cells for that volume scan.

This is likely the culprit. The storm looks consistent for all of the other volume scans. A dramatic dip in the attributes such as displayed here should be considered with caution, especially since it appears to return to its original strength the next volume scan. A good look at base reflectivity data (4-panel loop or all tilts) would probably give you the storm's true characteristics.

8/03

Worksheet
Reflectivity Derived Products

The following questions pertain to Reflectivity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. A thunderstorm moving at 45 mph has a VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has <u>not</u> changed appreciably.**

2. A storm which you have classified as a “mini supercell” is currently producing a tornado. The VILs with it are less than 20kg/m^2. Why?

3. The Cell-Based VIL (associated with the “main” cell of a very large storm complex 20 miles away from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?

4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?

5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) estimated on a given day?

6. Why are the VIL values sometimes unreliable beyond 100nm?

7. A member of the local media calls you up to say he’s using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?

8. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?

9. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely <u>not</u> be the primary tool for investigating storms in real time?

10. Why would you not expect to see hook echoes on a Composite Reflectivity?

11. What product allows you to depict a reflectivity layer with thickness of your choice anywhere from 0 to 70kft?

12. Why are the tops on the Echo Tops Product frequently displayed with a circular stair-stepped appearance?

13. Why do the tops on the Echo Tops product vary from the storm cell tops from the SCIT Algorithm (displayed on the Combined Attribute Table and in SCAN)?

Worksheet
Reflectivity Derived Products...ANSWERS!

1. A thunderstorm moving at 45 mph has a VIL considerably lower than the threshold you estimated earlier in the day. You get reports of quarter size hail. Can you explain? **Note: The airmass has not changed appreciably.**

   The speed is causing reflectivity on higher tilts to be spread to adjacent grid boxes. This will be more pronounced in VCP 21 in faster moving storms since it takes a minute longer.

2. A storm which you have classified as a “mini supercell” is currently producing a tornado. The VILs with it are less than 20kg/m^2. Why?

   A mini supercell is by definition low topped. The reflectivity core does not have great vertical extent. VIL (being a measure of the vertical extent of reflectivity) will be correspondingly low.

3. The Cell-Based VIL (associated with the “main” cell of a very large storm complex 20 miles from the RDA) has apparently decreased dramatically this volume scan. At the same time, the Grid VIL has remained high and fairly constant. Any explanation?

   Often large storms will have several “cells” identified with them. This may cause components to be mis-assigned when these cells are in close proximity. In this case, an adjacent cell probably got the components previously assigned to the “main” cell. The result may be that cell based output may be adversely affected.

4. In what instances might the Cell-Based VIL be higher than the Grid VIL for a particular storm?

   If a storm is fast moving or strongly tilted, it can retain more of its definition in the Cell-Based VIL (assuming it has been correctly identified by the algorithm) while in the Grid VIL, upper and lower cores may end up in adjacent grid boxes.

5. How are critical VIL thresholds (values which correlate with 3/4 inch hail) estimated on a given day?

   The operator must consider the environment, make an estimate, and then verify it with ground truth. There may be other ways (possibly relating the Wet-Bulb Zero or using VIL Density), but they too should use ground truth to verify.

6. Why are the VIL values sometimes unreliable beyond 100nm?

   The algorithm assumes the dBZ values at 0.5 degrees extend to the surface. This may cause mid and high topped storms to have overestimated VILs, and low-topped convection to have underestimated VILs.

7. A member of the local media calls you up to say he's using the information on the Composite Reflectivity attribute table to locate a TVS listed there. However, at the AZ/RAN listed, he sees no evidence of a circulation. Is this TVS a false alarm?

    The azimuth and range listed on the Composite Reflectivity Combined Attribute Table (to which NIDS users do have access), is that of the *storm cell* whose ID is listed on the table. That AZ/RAN, which comes from the SCIT algorithm, is the location of the cell's 3-D center of mass, not the location of any TVS or MESO which may be associated with the storm. In order to locate the AZ/RAN of any TVSs (and there may be more than one) which are "associated" with this storm, one must look at the TVS product (which NIDS users do NOT have access to.) In this case, all anyone can tell by looking at the CR attribute table is that there is at least 1 TVS detected during this volume scan that was given the ID of the storm listed.

8. What two radar limitations cause the bases and tops of echoes in cross sections to be truncated?

    Bases will be truncated due to the radar horizon effects.
    Tops will be truncated due to scan strategy effects.

9. While cross sections can show storm structure and the depth of the reflectivity core, why will they likely not be the *primary* tool for investigating storms in real time?

    It can be hard to get placement just right. It also takes time and is always from the previous volume scan.

10. Why would you not expect to see hook echoes on a Composite Reflectivity?

    Echo overhang will usually obliterate it.

11. What product allows you to depict a reflectivity layer with thickness of your choice anywhere from 0 to 70kft?

    User Selectable Layer Reflectivity Maximum (ULR)

12. Why are the tops on the Echo Tops Product frequently displayed with a circular stair-stepped appearance?

    It uses the height of the beam center point. Because the beam is so large at far ranges, the altitude change from one slice to the next adjacent slice can be much more dramatic. Also it uses 5kft increments.

13. Why do the tops on the Echo Tops product vary from the storm cell tops from the SCIT Algorithm (displayed on the Combined Attribute Table and in SCAN)?

    The ET product uses the height of the 18.3 dBZ echo.
    The Storm/Cell Top uses the height of the highest component (at least 30 dBZ).

8/03

Review Exercises
Reflectivity Derived Products

Instructions: Select the <u>most</u> correct answer. Questions 8-11 require the figures provided.

1. True or False Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.

2. Which of the following statements about the Composite Reflectivity product is <u>true</u>?

   a) The height of the maximum reflectivity for each resolution grid box is known.
   b) The product is useful for locating hook echoes, when present with a storm.
   c) Echo aloft can <u>not</u> be discriminated from precipitation reaching the surface.

3. The Echo Tops product will be useful for distinguishing:

   a) between liquid and frozen precipitation.
   b) the height of higher dBZ's.
   c) AP from precipitation echoes.

4. True or False The value of the ULR product is that you can choose a layer which highlights an area of interest, such as the altitude of the bright band.

5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:

   a) to estimate storm top divergence.
   b) the combined attribute table is available.
   c) to evaluate the height of higher dBZ's.

6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:

   a) The location of BWERs when present.
   b) echo development aloft.
   c) the max dBZ in a storm.

7. Which of the following products may be effective for detecting storms with $\geq$ 3/4 inch hail? (More than one answer possible).

   a) Hail Index
   b) Echo Tops
   c) Vertically Integrated Liquid
   d) Reflectivity Cross Section
   e) Layer Composite Reflectivity Maximum
   f) Composite Reflectivity
   g) Storm Track

Questions 8-11 use the figures provided.

8. **True or False** A bounded weak echo region is located on the west side of the storm depicted in the cross section.

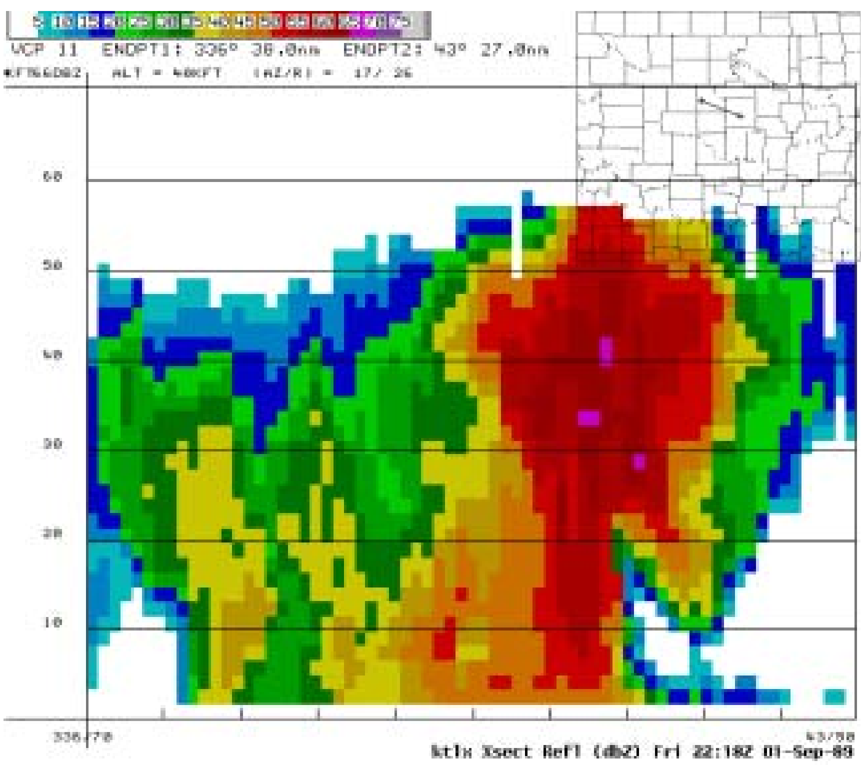


Figure 1. Reflectivity Cross Section.

9. Using the four-panel reflectivity product, this storm is exhibiting:

   a) Convergence
   b) A weak echo region.
   c) A bounded weak echo region.

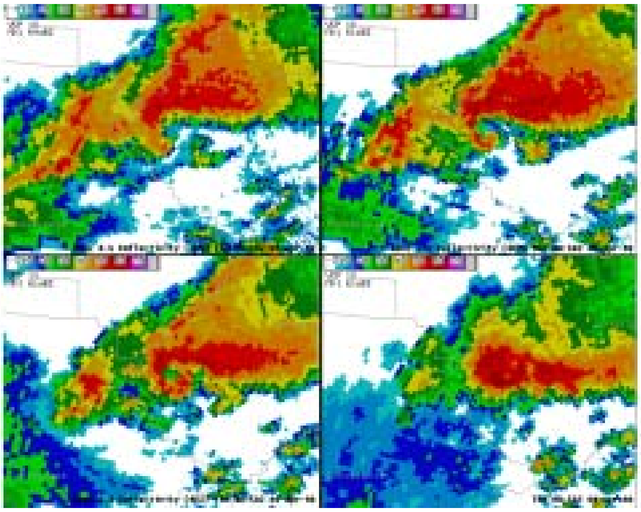


Figure 2. Four panel reflectivity centered 30 miles northwest of the RDA.

10. The narrow "spike" depicted between 30kft and 40kft on the left storm in the cross section is:

   a) A result of interpolation in the current scan strategy.
   b) A Three-Body Scatter Spike, indicative of large hail.
   c) Related to algorithm failure.

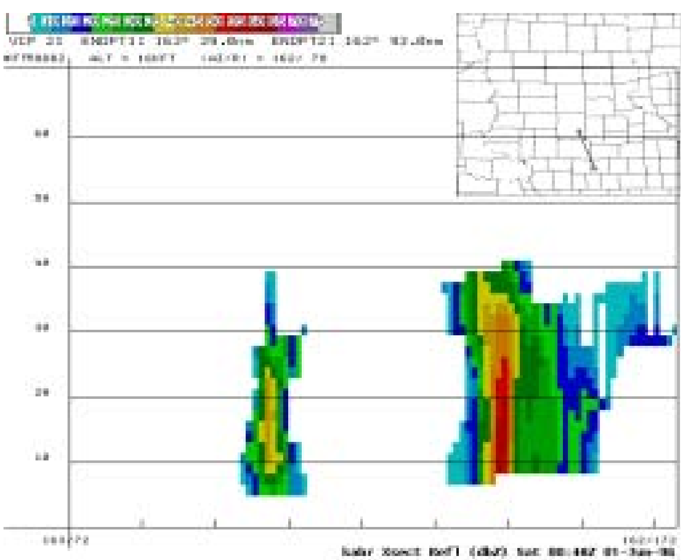


Figure 3. Reflectivity Cross Section.

11. It's summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch

is in effect. The VIL threshold estimated on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?

a) Issue a severe thunderstorm warning.
b) Issue a tornado warning.
c) Wait for another volume scan to make a decision.
d) Wait for spotter confirmation to make a decision.

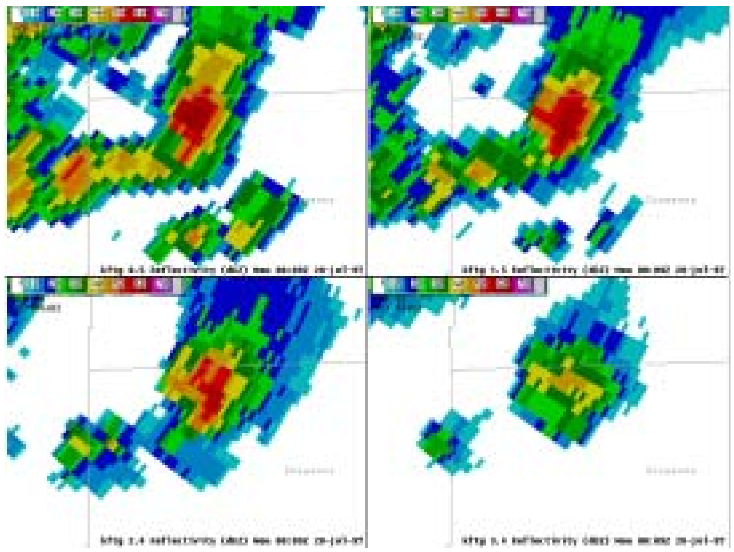


Figure 4. Four panel reflectivity product. The range to the storm is around 90nm. The altitude of 2.4 degree slice is around 28Kft. The altitude for the 3.4 degree slice is near 37Kft.

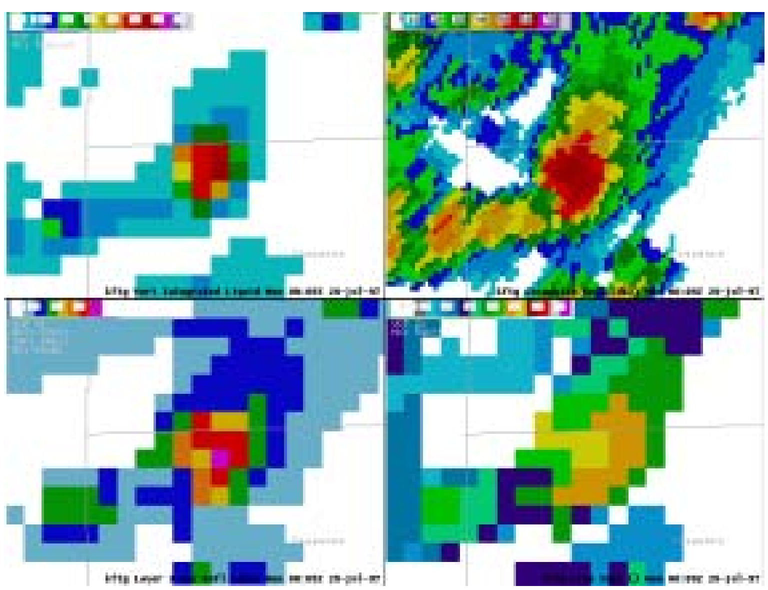


Figure 5. VIL(max 55), CR (max 60dBZ), LRM-M (max 57dBZ) and ET(max 50Kft) product for the same storm at the same time.

Review Exercises
Reflectivity Derived Products
*******ANSWERS*******

Be sure to check each answer if you are not sure why they are wrong or right.

1. True or False Cell-Based VIL will *usually* be more accurate than Grid VIL for a fast moving storm.
The answer is TRUE. Remember that Cell-Based VIL will attempt to identify the cell even when the upper components are not vertically stacked. Grid VIL will likely underestimate the storm as the upper components will fall in grid boxes adjacent to those for the lower components. This is due to the continued motion of the storm during the time it takes to complete the volume scan.

2. Which of the following statements about the Composite Reflectivity product is true?
a) The height of the maximum reflectivity for each resolution grid box is known.
No way! This is one of the limitations of the CR product. You do NOT know from what elevation angle each reflectivity value comes.

b) The product is useful for locating hook echoes, when present with a storm.
Egad! This is NOT where you want to look for hook echoes or pendants. It would be a misapplication of this product (kinda like using a toaster to make Jell-O - nothing wrong with the toaster...except if you're using it to make Jell-O!) In a CR product, the echo overhang often masks the hook echo. You would therefore refer back to a Base Reflectivity product for this feature.

c) Echo aloft can not be discriminated from precipitation reaching the surface.
Very true! This is why you don't want to use this product to brief anyone on where it may or may not be raining. Echo aloft (such as cirrus anvil) may look exactly like light rain. Comparing the CR to a Base Reflectivity product will help make this discrimination.

3. The Echo Tops product will be useful for distinguishing:
a) between liquid and frozen precipitation.
Sorry. It will give an estimate of the top of the echo, but will tell you nothing about precipitation type or intensity.

b) the height of higher dBZ's.
Incorrect. Think about this for a second. You know that at the height indicated on this product, there is echo of 18.3dBZ or greater. But that is all you know. You don't know anything about the height of the 30dBz core or the 50dBZ core, for example. You would want to use a cross section or a 4panel Reflectivity product or the *All Tilts* feature on AWIPS for that.

c) AP from precipitation echoes.
Yes. Since AP doesn't usually have much vertical extent, this is a good

application of this product.

4. True or <u>False</u> The value of the ULR product is that you can choose a layer which highlights an area of interest, such as the altitude of the bright band.

True. You can choose any depth so long as the thickness is at least 1kft.

5. When examining a thunderstorm, one strength of the Reflectivity Cross Section product is:

a) to estimate storm top divergence.

Negative. You need velocity to estimate divergence. This will be an application of the Velocity Cross Section to be discussed later.

b) the combined attribute table is available.

No. Sometimes people will confuse the names of the Reflectivity Cross Section and the Composite Reflectivity (which *does* have an attribute table with it). If you picture the RCS, you will likely remember that this is *not* where you find the Combined Attribute Table.

<u>c) to evaluate the height of higher dBZ's.</u>

Yes! You must be careful with the placement of the cross section line through the storm, but you can use the resulting RCS to evaluate the height of the 50 dBZ core, for example.

6. The Layer Composite Reflectivity Maximum *mid-level* product will often be useful in determining:

a) The location of BWERs when present.

No! Any BWER which is present in mid levels will likely be masked by higher reflectivity echo above the BWER in that layer. Just as the CR product is not the place to look for signatures such as pendants and hook echoes, the LRM, which basically uses the same process, should also not be used for this purpose.

<u>b) echo development aloft.</u>

Yes! A great application of this product is with elevated convection. You can often see the mid-level development on this product before anything shows up at the surface. This could lead to valuable lead-time for pulse thunderstorms in the summertime.

c) the max dBZ in a storm.

Close! You can see the max dBZ in that *layer*, but you would have to check all three layers to determine the max in the storm.

7. Which of the following products may be effective for detecting storms with $\geq$ 3/4 inch hail? (More than one answer possible).

a) Hail Index - ***make sure environmental data is representative***

b) Echo Tops - ***effects of scan strategy on underestimation***

c) Vertically Integrated Liquid - ***"significant" values change with environment***

d) Reflectivity Cross Section - ***how well you see storm depends on the cut taken***
e) Layer Composite Reflectivity Maximum - ***mid/high level, depends on environment***
f) Composite Reflectivity - ***shows max in storm, but you don't know what height***
g) Storm Track - ***could infer something from the attribute table readout which shows the max dBZ and its height***

Answer: Each of these can be effective *when used properly* in the decision making process. You will want to keep in mind the strengths and limitations of each (some of which are listed above), in conjunction with sampling limitations, and be sure to use them with other products. Keep in mind that the lack of convincing evidence on any one product could be a result of these limitations, rather than an actual representation of the storm.

8. **True or <u>False</u>** A bounded weak echo region is located on the *west* side of the storm depicted in the cross section.
False! This is sort of a 2-part question: 1)Do you recognize a BWER, and 2) Can you tell what orientation the cross section samples the storm? Both are important. The cross section does show a BWER, however it is on the *east* side of the storm. Remember that the origin of a cross section is the western-most point, unless the line is along the same longitude - in which case the origin is the northern-most point.

9. Using the four-panel reflectivity product, this storm is exhibiting a:
a) Convergence
It may well have convergence but we'd need a velocity product to see this.

b) Weak echo region.
Yes but "c" is probably a better answer.

c) Bounded weak echo region.
Yes! In a four panel, the BWER will show up as a "donut". The storm exhibits a hook in quadrant 1 , almost a complete BWER in quadrant 2, and a definite BWER (donut) in the 3rd (lower left) quadrant.

10. The narrow "spike" depicted between 30kft and 40kft on the left storm in the cross section is:

a) A result of interpolation in the current scan strategy.

Yes. The cross section process interpolates from one elevation cut to the next higher cut where data are detected. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process when used with discrete elevation sampling.

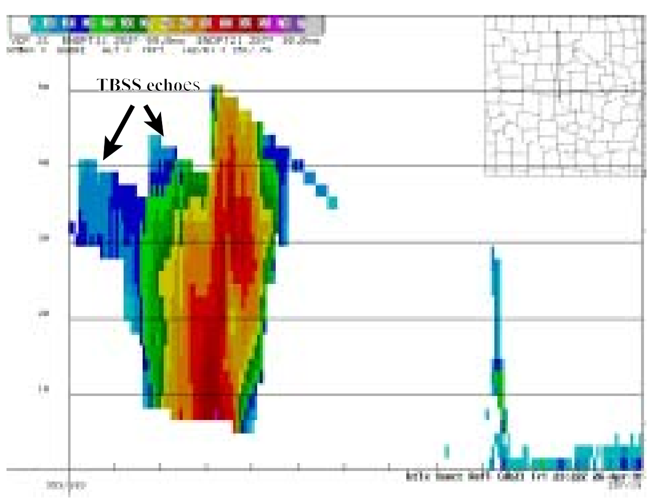
b) A Three-Body Scatter Spike, indicative of large hail

No. This is not a three-body scatter spike. The cross section process interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice (looks like it was around 5dBZ). It then had to interpolate between that pixel and whatever was below it on the previous slice This is indeed an artifact of the interpolation process.

For an example of a TBSS, look at figure the figure below. This on the other hand, is a three-body scatter spike as shown in a cross section. The TBSS is the weak reflectivities which extend *down-radial* from the high reflectivity core.

c) Related to algorithm failure

No - the algorithm did what it was suppose to do and that is interpolate between elevation cuts. The cross section process interpolates from one elevation cut to the next higher cut. This cross section obviously went through two pixels of reflectivity at the higher slice. It then had to interpolate between that pixel and whatever was below it on the previous slice. This is indeed an artifact of the interpolation process.



11. It's summertime in the Rockies. Thunderstorms have developed in the monsoon moisture streaming northward. On the day in question, a severe thunderstorm watch is in effect. The VIL threshold estimated on this day is approximately 45. After looking at the information provided, what kind of action would you take for the storm centered in each of the products?

    a) Issue a severe thunderstorm warning.
    b) Issue a tornado warning.
    c) Wait for another volume scan to make a decision.
    d) Wait for spotter confirmation to make a decision.

    Considerations: The four panel shows 50-55dBZ extending up at least to 28kft or higher. The LRM-M indicates at least 57 dBZ somewhere in the layer between 24-36kft. The VIL is above your threshold of 45 (for 3/4 inch hail) but it is at a fairly long range and may be slightly overestimated. The CR product is detecting 60dBZ although it doesn't show up in any of the 4 slices in the 4-panel.

    Warning Decision:
    Issue a SVR: If you were to issue an SVR, it should be now (or maybe a while ago). Otherwise, you will have no lead time. The vertical extent of the high reflectivity core is significant enough that you would expect fairly large hail (considering the time of year and the environment). This is supported by the VIL values as well as the size of the core as represented by the VIL product. All the other product input supports this as well. Sampling limitations seem to be having a minimal impact on the storms presentation.

    Issue a TOR: This is a possibility. However, as far as a tornado warning goes, what *information provided here* would support this decision? Probably very little.

    Wait for another volume scan: You could also do this. If you choose to wait, you should have in mind <u>what it is you're waiting to see</u> which will cause you to warn. Frankly, we've seen enough.

    Wait for spotter input: You could also do this. Something to keep in mind is what kind of input would you want to hear that would cause you to issue a warning (and still have positive lead time.) Also remember there are times and places where spotter reports are few and far between...don't wait on them if other inputs are convincing.

    What happened: There is no right or wrong answer. There are however, good decisions which will stand up to any scrutiny, regardless of the outcome, and bad decisions which may be based on erroneous information or logic. A good decision here is one based on the proper use of all the information provided, including the strengths and limitations of the products as well as the radar. This storm had a history of producing golfball hail and would produce nickel size hail shortly.

9/03

Worksheet
Velocity Derived Products

The following pertain to the Velocity Derived Products. Answer them if you desire a little extra practice. The answers are included at the end of the worksheet.

1. What is the default storm motion for the .54nm Storm-Relative Mean Radial Velocity Map (SRM) product?

2. What is the default storm motion for the Storm-Relative Mean Radial Velocity Region (SRR) product?

3. What is the default storm motion for the 8-bit SRM product display?

4. For the phenomena listed below, which product would be most effective? (Choose either 8-bit SRM product display, or 8-bit Velocity product.)

   a) Mesocyclones in a series of fast moving storms_______________________

   b) Winds associated with a bow echo 20 miles from the RDA______________

   c) A hurricane____

   d) Residual outflow boundaries on a summer day before convection develops____

5. Under what situation would you choose to request the.54nm SRM versus the 8-bit SRM?

6. How many elevation angles of an SRM product (either 4-bit or 8-bit) are appropriate on an RPS List at a lan-lan site? Which angles are best?

7. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?

8. What is the difference between a mesocyclone and a 3-D Correlated Shear?

9. What will be the impact of lowering the threshold pattern vectors (TPV) in the mesocyclone algorithm from 10 to 6? In what situation would you want to make this change?

10. What are the possible entries you can make on the RPS list for inclusion of the Mesocyclone Rapid Update product?

11. In which situation, isolated convection or squall line, would there likely be more detections by the TVS algorithm?

12. How do you validate detections by either the mesocyclone or TVS algorithms?

13. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?

14. State two reasons why the depiction of a feature on the SRR product may be more representative than the same feature depicted on the .54 nm SRM?

15. Why is the SRM product usually placed on the RPS list, while the SRR product is not?

16. Why would you find the <u>max</u> inbound and outbound winds more useful on the SRR product than the SRM product?

Worksheet
Velocity Derived Products
*******ANSWERS*******

1. What is the default storm motion for the .54nm Storm-Relative Mean Radial Velocity <u>Map</u> (SRM) product?

The average motion of all identified storms. The average will be from the previous volume scan.

2. What is the default storm motion for the Storm-Relative Mean Radial Velocity <u>Region</u> (SRR) product?

The motion of the storm closest to the product center. This also will be from the previous volume scan.

3. What is the default storm motion for the 8-bit SRM product display?

Your choice of either 1) the most recent motion used by WARNGEN or the radar tools feature, 2) the average of all identified storms from the SCIT algorithm (same as the 4-bit SRM), or 3) a user supplied motion.

4. For the phenomena listed below, which product would be most effective? (Choose either 8-bit SRM product display, or 8-bit Velocity product.)

   a) Mesocyclones in a series of fast moving storms
   8-bit SRM as the storm motion would be subtracted out
   b) Winds associated with a bow echo 20 miles from the RDA
   8-bit Velocity since you want ground relative winds
   c) A hurricane
   8-bit Velocity since storm motions used in a hurricane situation are usually not representative.
   d) Residual outflow boundaries on a summer day before convection develops
   8-bit Velocity or 8-bit SRM (depending on default motion setting). The Hi-res velocity will give you ground relative winds. The 8-bit SRM will also give ground relative winds IF the default motion is set to that provided by the SCIT since no storm are identified, or it is operator set at 0deg, 0kts)

5. Under what situation would you choose to request the.54nm SRM versus the 8-bit SRM?

Where band-width issues must be considered, as with non lan-lan connections. In addition, the ALL TILTS function currently only works with the 4-bit SRM product.

6. How many elevation angles of an SRM product (either 4-bit or 8-bit) are appropriate on an RPS List at a lan-lan site? Which angles are best?

At least 4 elevation angles (to place in a 4panel R/SRM). The angles you choose will depend on your VCP and the range to the storms (low and high angles for storms close in, low angles for storms far out). For proper storm interrogation, you will also want to choose angles which will sample storms and low, mid, and high levels. With a lan-lan connection, you can add additional slices which would make it easier to select a variety of 4panels. In order to take advantage of the ALL TILTS feature, you

would want several slices of the .54nm SRM (ALL TILTS currently only works with the 4-bit SRM).

7. What type of Velocity Cross Section orientation is necessary to examine the depth of a mesocyclone in a storm?

To see circulation, you will want a VCS perpendicular to the beam. Try to center the line at the center of the mesocyclone.
(To evaluate low level convergence, updraft/downdraft interface, and upper level divergence, you need a VCS along a radial.)

8. What is the difference between a mesocyclone and a 3-D Correlated Shear?

In the MESO algorithm, the only difference between these two is the mesocyclone meets symmetry criteria, and the 3DC does not.

9. What will be the impact of lowering the threshold pattern vectors (TPV) in the mesocyclone algorithm from 10 to 6? In what situation would you want to make this change?

Lowering the requirement for the number of pattern vectors in an identified feature will allow smaller features to be detected. You might want to do this in situations where small scale, low topped, or shallow features are expected.

10. What are the possible entries you can make on the RPS list for inclusion of the Mesocyclone Rapid Update product?

You can choose to receive this product at 1)specific angles, 2) all angles, or 3) the lowest “n” angles.

11. In which situation, isolated convection or squall line, would there likely be more detections by the TVS algorithm?

Regardless of the parameter set used, squall line convection will usually result in more algorithm detected features. Many of these will not be considered significant by the operator as they can be associated with transient shears along the gust front.

12. How do you validate detections by either the mesocyclone or TVS algorithms?

ALWAYS refer to the base data to assess the validity of an algorithm detection. Consider its base data attributes, its location, the environment, and any input gleaned from spotters or storm history.

13. Which product would you examine to check wind data that appears "suspicious" on the VAD Wind Profile?

If winds look funky on the VWP, you can do a one-time-request for a VAD wind at the offending altitude. You can then see the actual sample points and their relationship to the plotted sine wave.

14. State two reasons why the depiction of a feature on the SRR product may be more representative than the same feature depicted on the .54 nm SRM?

The SRR has better resolution and should use a better storm motion than the SRM.

15. Why is the SRM product usually placed on the RPS list, while the SRR product is not?

Even though the SRR should give better results, it is not likely to be put on the RPS List since it has a limited viewing range and requires an AZRAN centerpoint (which you don't know ahead of time). Most often, operators will put several SRMs on the RPS list and get a good quick look at potential circulations. Then if time permits, they may choose to do a one-time request the SRR on a storm in particular.

16. Why would you find the max inbound and outbound winds more useful on the SRR product than the SRM product?

The max inbound/outbound velocities are more useful on the SRR because they only apply to the small window product. It is difficult to use these values on the SRM because they may refer to anywhere on the product, not just a storm of interest.

8/03

REVIEW EXERCISES
Velocity Derived Products

Instructions: Select the <u>most</u> correct answer. Questions 11 and 12 use the supplied figures. Answers are attached. No peeking allowed.

1. When the ground-relative winds are important, what should be used?

    a) 8-bit Base Velocity
    b) Storm Relative Region with the default storm motion
    c) 4-bit Storm Relative Map product with the default storm motion

2. What product must be in the database in order to generate an 8-bit SRM product display?

    a) 4-bit SRM product
    b) 8-bit Base Velocity
    c) Storm Relative Region
    d) You don't need any special product to view the 8-bit SRM.

3. If a Velocity Cross Section is generated along a radial, the operator can evaluate the __ .

    a) strength of a circulation
    b) depth of a mesocyclone
    c) the strength of the storm top divergence

4. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.

5. Which product is beneficial as an alert paired product for TVS or MESO detections?
    a) Base Velocity product
    b) Storm-Relative Mean Radial Velocity Map
    c) Storm-Relative Mean Radial Velocity Region

6. Which of the following statements concerning the Mesocyclone product is <u>true</u>?

    a) A 3-D Correlated Shear is a precursor to a mesocyclone.
    b) The algorithm mesocyclone must contain circulations that are at least 10,000 ft deep.
    c) Time continuity is not employed.

7. **True or False** The TDA algorithm only searches identified mesocyclones for the

occurrence of a TVS or ETVS.

8. Which of these is true about the TDA algorithm and TVS product?

    a) Isolated severe convection will usually produce more false alarm detections than squall line situations.
    b) TVS detections represent gate-to-gate shear signatures.
    c) Identified TVSs will always have their bases on the lowest elevation angle.

9. One strength of the <u>VAD</u> <u>Wind</u> <u>Profile</u> is to display the:

    a) strength of a low level jet.
    b) symmetry error.
    c) sine wave curve.

10. Which of these products are you likely to have on your RPS List to help you evaluate the strength and depth of mesocyclones?

    a) VAD
    b) Velocity Cross Section
    c) Storm-Relative Mean Radial Velocity Region
    d) Storm-Relative Mean Radial Velocity Map

Question 11 uses the figure provided.

11. Using figure 1, the winds appear reasonably accurate in the 10,000 - 15,000 ft range since __ .

    a) the symmetry is near zero
    b) the RMS error is low
    c) there are only a few "ND" points

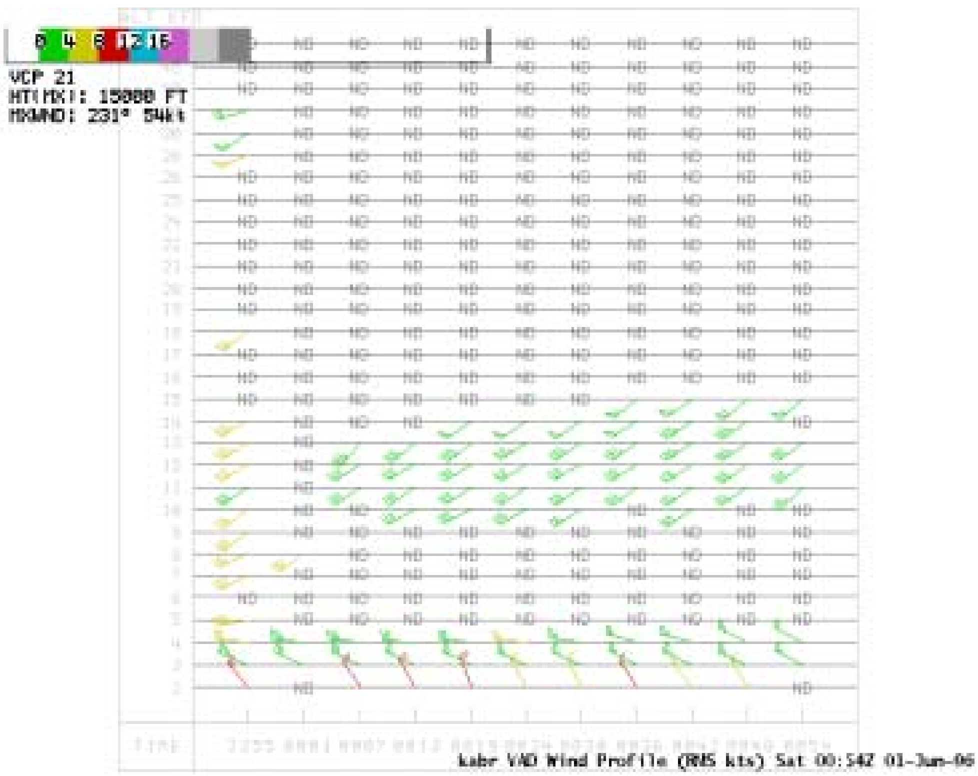


Figure 1. VAD Wind Profile.

12. Which of the following can be said of the Mesocyclone Rapid Update Product?

    a) The algorithm tries to employ some time continuity by correlating features in adjacent volume scans.
    b) The produce can only be requested at low, middle and high elevation cuts.
    c) The classification of *increasing* always means that the feature has strengthened.
    d) The attribute table associate with the product only contains information regarding detections in the current volume scan.

REVIEW EXERCISES
Velocity Derived Products
******ANSWERS******

Be sure and check each answer if you're not sure why each is wrong or right.

1. When the ground-relative winds are important, what should be used?

   a) 8-bit Base Velocity
   Absolutely! If looking for the strength of gradient winds or the strength of a gust front, you want *ground relative* winds (no storm motion subtracted out). All the Base Velocity products are ground relative by definition. The higher the resolution you can use, the more complete the information will be.
   b) Storm Relative Region with the default storm motion
   No. It would be a mis-application of the SRR or the SRM to use either one to detect ground relative winds. Their strength is in subtracting out storm motion to see rotational signatures, not in assessing ground relative winds.
   c) 4-bit Storm Relative Map product with the default storm motion
   No. It would be a mis-application of the SRR or the SRM to use either one to detect ground relative winds. Their strength is in subtracting out storm motion to see rotational signatures, not in assessing ground relative winds.

2. What product must be in the database in order to generate an 8-bit SRM product display?

   a) 4-bit SRM product
   b) 8-bit Base Velocity
   This is the correct answer. The 8-bit SRM is NOT a product produced by the RPG. It is a display that AWIPS creates on the fly using the 8-bit Base Velocity product.
   c) Storm Relative Region
   d) You don't need any special product to view the 8-bit SRM.

3. If a Velocity Cross Section is generated along a radial, the operator can evaluate the _

   a) strength of a circulation.
   False. While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities

(at approximately the same range.) You do not have adjacent azimuths if the VCS is taken along a radial.

b) depth of a mesocyclone.

False. While you can use a VCS to estimate this, the cross section needs to be *perpendicular to the radial* and centered on the feature. One way to remember this is that in order to see rotation, you must see more than one azimuth, which shows inbound velocities adjacent to outbound velocities (at approximately the same range.) You do not have adjacent azimuths if the VCS is taken along a radial.

c) the strength of the storm top divergence

Yes. A VCS taken down radial, especially through the inflow side of the storm, can allow you to infer convergence at low levels, the updraft/downdraft interface, and storm top divergence.

4. **True or False** The VAD algorithm needs at least 180 degrees of data before it will fit a sine wave to the data points.

The answer is False! The VAD algorithm need 25 data points (from 25 degrees of data) in order to make an attempt to fit a sine wave to the points. This means it can still get pretty good estimates even when there is not widespread echo. This is a strength of the algorithm.

5. Which product is beneficial as an alert-paired product for TVS or MESO detections?

a) .54 nm Base Velocity product

Probably not. You don't want to use this product to look for circulations.

b) Storm-Relative Mean Radial Velocity Map

Probably not. Chances are you are already getting this anyway. While it's not a bad product, there is one better suited.

c) Storm-Relative Mean Radial Velocity Region

This is probably the best choice. This product when used as an alert-paired product will be centered on the feature which triggered the alert. It is also more likely to use an appropriate storm motion since it uses the motion of the storm closest to the product/window center. Finally, this is not a product you are normally getting on your RPS list so getting it here would not be redundant.

6. Which of the following statements concerning the Mesocyclone product is <u>true</u>?

a) A 3-D Correlated Shear is a precursor to a mesocyclone.

Don't be fooled! Whether or not a feature gets classified as a 3-D Correlated Shear (3DC) or a MESO is a measure of "symmetry", i.e. how close the azimuthal diameter is to the diameter along the radial. This could be entirely a function of sampling! Features may go back and forth between

these two classifications merely because of sampling, not because of anything meteorological.

b) The Meso algorithm requires circulations to be at least 10,000 ft deep.

The algorithm's "depth requirement" is *at least 2 elevation cuts*. This could be substantially less than 10Kft if the feature is very close to the radar. This is why very shallow features, along a gust front nearing the radar for example, may be classified as MESOs. The *operator* identification of a mesocyclone uses the 10Kft depth as an approximation for height continuity. (The operator of course may choose to lower this value depending on the overall depth of the storm).

c) Time continuity is not employed.

Yes! The Mesocylcone algorithm does not employ time continuity. Transient shears which pass all other tests may be identified one volume scan and lost the next. Once again it is the operator who must employ time continuity to help weed out transient shears. (Note the **MRU** algorithm does employ time continuity somewhat by correlating features between volume scans)

7. **True or False** The TDA algorithm only searches identified mesocyclones for the occurrence of a TVS or ETVS.

False! The TDA algorithm returns to the base velocity data to do its processing and runs independently of the mesocyclone algorithm.

8. Which of these is true about the TDA algorithm and TVS product?

a) Isolated severe convection will usually produce more false alarm detections than squall line situations.

False. The algorithm usually works best with isolated severe convection.

b) TVS detections represent gate-to-gate shear signatures.

True. The algorithm is only searching gate-to-gate features.

c) Identified TVSs will always have their bases on the lowest elevation angle.

False. TVSs close to the radar can actually be on higher slices as long as they are below 600m.

9. One strength of the <u>VAD</u> <u>Wind</u> <u>Profile</u> is to display the:

a) strength of a low level jet.

Absolutely! This is something you can evaluate time and height wise using the VWP.

b) symmetry error.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve, from which the algorithm calculates symmetry (the first term in the least squares equation on the bottom of the product). In contrast, the VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

c) sine wave curve.

You are probably confusing the VAD with the VWP. The VAD is where you find the sine curve The VAD Wind Profile shows the wind barbs plotted with time and height (much like the profilers).

10. Which of these products are you likely to have on your RPS List to help you evaluate the strength and depth of mesocyclones?

a) VAD

Not even close! You may well put this on your RPS List, but it will not help you with evaluating mesocyclones. Recall that the VAD works best in homogeneous wind flow situations and was not designed to diagnose small scale rotations. It can also help you diagnose suspicious winds on the VWP. However, it will tell you nothing about a small scale feature such as a Meso.

b) Velocity Cross Section

Sort of close. You can use a VCS to evaluate the depth and strength of a mesocyclone, however, you will likely NOT have this on your RPS list since you don't know where the circulation will be ahead of time.

c) Storm-Relative Mean Radial Velocity Region

You're half right. You can use SRR to evaluate depth and strength of a mesocyclone, however, you will likely NOT put SRRs on your RPS list since you don't know where the circulation will be ahead of time.

d) Storm-Relative Mean Radial Velocity Map

This is the one! No doubt, most convective RPS Lists at most dedicated user sites in the country have several slices of SRM on them to help evaluate the strength and depth of mesocyclones. Most sites will also have matching procedures to quickly display 4 elevations of the SRM to help in the evaluation. (Note: to use the 8-bit SRM to evaluate these features, you need the 8-bit Velocity product on the RPS List).

Question 11 uses the figure provided.

11. Using figure 1, the winds appear reasonably accurate in the 10,000 - 15,000 ft range since __

a) the symmetry is near zero.

Not really. While the symmetry may indeed be near zero, there is no way to tell that from this product. You'd have to go to a VAD in order to see that.

b) the RMS error is low.

Yes! The RMS error is a measure of how well the sine curve fits the sample points. The lower it is, the better the fit. The better the fit, the more representative the wind calculated from that sine curve will be. The RMS error for these winds (which we can see via the color coding) is very low.

c) there are only a few "ND" points.

Sorry. Data sampled for one altitude really has nothing to do with those sampled at another altitude. You may very well have almost all altitudes

showing ND, with only one or two winds being plotted. If the RMS error is low for these winds (note color table), then you can infer they are reasonable. You may simply have had no scatterers at the altitudes where you have ND.

12. Which of the following can be said of the Mesocyclone Rapid Update Product?

a) The algorithm tries to employ some time continuity by correlating features in adjacent volume scans.

Yes. By using the storm track output to move features along to the next volume scan, the MRU employs some time continuity between adjacent volume scans.

b) The produce can only be requested at low, middle and high elevation cuts.

This product can be requested in lots of ways - either for individual cuts, all cuts, or for a specified number of cuts starting from the lowest.

c) The classification of *increasing* always means that the feature has strengthened.

Not necessarily. The classification of *increasing* can mean there is an increase in shear but it can also result from the feature going from 3DC to Mesocyclone. The latter is a result in the symmetry calculation for the feature and may not indicate strengthening.

d) The attribute table associate with the product only contains information regarding detections in the current volume scan.

Nope. The attribute table will contain information from the current and previous volume scan. The inputs from the previous volume scan will be retained unless or until their values increase in the current volume scan.

Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

1. _____ Resolution 1.1nm x 1 degree
2. _____ Resolution 0.54nm x 1 degree
3. _____ Updated each volume scan
4. _____ Updated at the top of the hour
5. _____ 16 Data levels
6. _____ 256 Data levels
7. _____ Available as an alphanumeric product only
8. _____ Not displayable at WFO AWIPS workstation
9. _____ corresponds to the Flash Flood Guidance time interval
10._____ can be generated for a specified period of time

A. Digital Hybrid Reflectivity (DHR)
B. Hybrid Scan Reflectivity (HSR)
C. One Hour Precipitation (OHP)
D. Three Hour Precipitation (THP)
E. Storm Total Precipitation (STP)
F. User Selectable Precipitation (USP)
G. Digital Precipitation Array (DPA)
H. Supplemental Precipitation Data (SPD)

Identify true statements below with a T and false statements with an F.

10._____ The digital Three Hour Product is used directly by RFC computers as input to the hydrologic models (NWSRFS).

11._____ The Precipitation Processing Subsystem can eliminate any hail contamination.

12.____ Missing volume scans do not affect the accuracy of the radar precipitation estimates.

13.____ A multiplicative bias is calculated in AWIPS using rain gauge to radar comparisons, and sent to the RPG.

14.____ The Precipitation Processing Subsystem algorithms contain significant quality control steps.

15.____ Adjusting the Nominal Clutter Area suppresses Anomalous Propagation and thus reduces the contamination of precipitation estimates.

****

For all questions on this page, assume that the rainfall event occurred in a 6 hour period, and that the flash flood guidance given is for 6 hours. Each of the 3 figures should be treated as separate events.

****

For questions 16 and 17, use Fig. 1.

16. In ________________county, the radar data is______________due to ___________________________________.

A. Y...unreliable...evidence of double bright band contamination.
B. X...unreliable...evidence of overestimation.
C. Z...reliable...good rain gage correlation.
D. Y...unreliable...evidence of underestimation.

17. Rain occurred shortly after Flash Flood Guidance issuance time. The rain event that you see in Figure 1 occurred much later in the day, after a period of clear air (category 0). Thus the Flash Flood Guidance was invalid for the duration of this event. Which of the above counties would be the HIGHEST priority for further investigation?

For question 18, use Fig. 2 and 6 hour Flash Flood Guidance 4.9 inches for all counties.

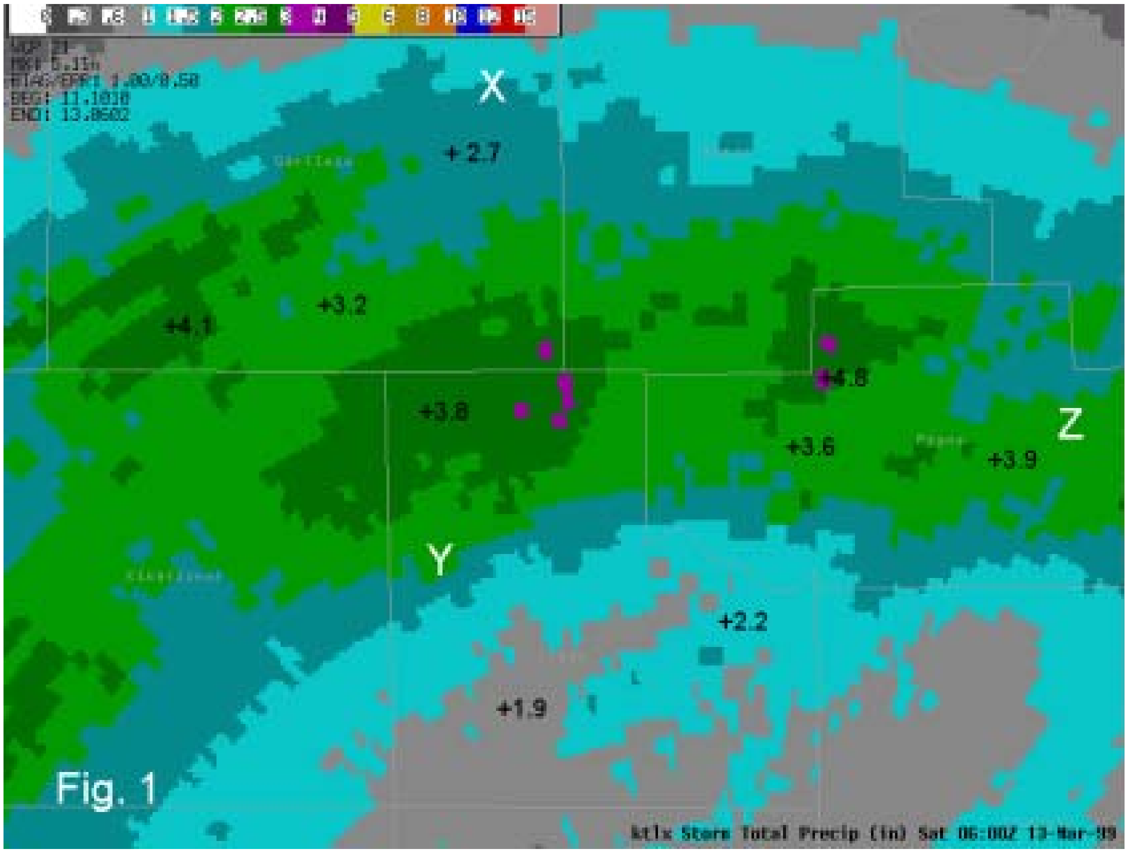
18. Using the STP as a "first look", ________________county would be the HIGHEST priority for further investigation of flash flooding.

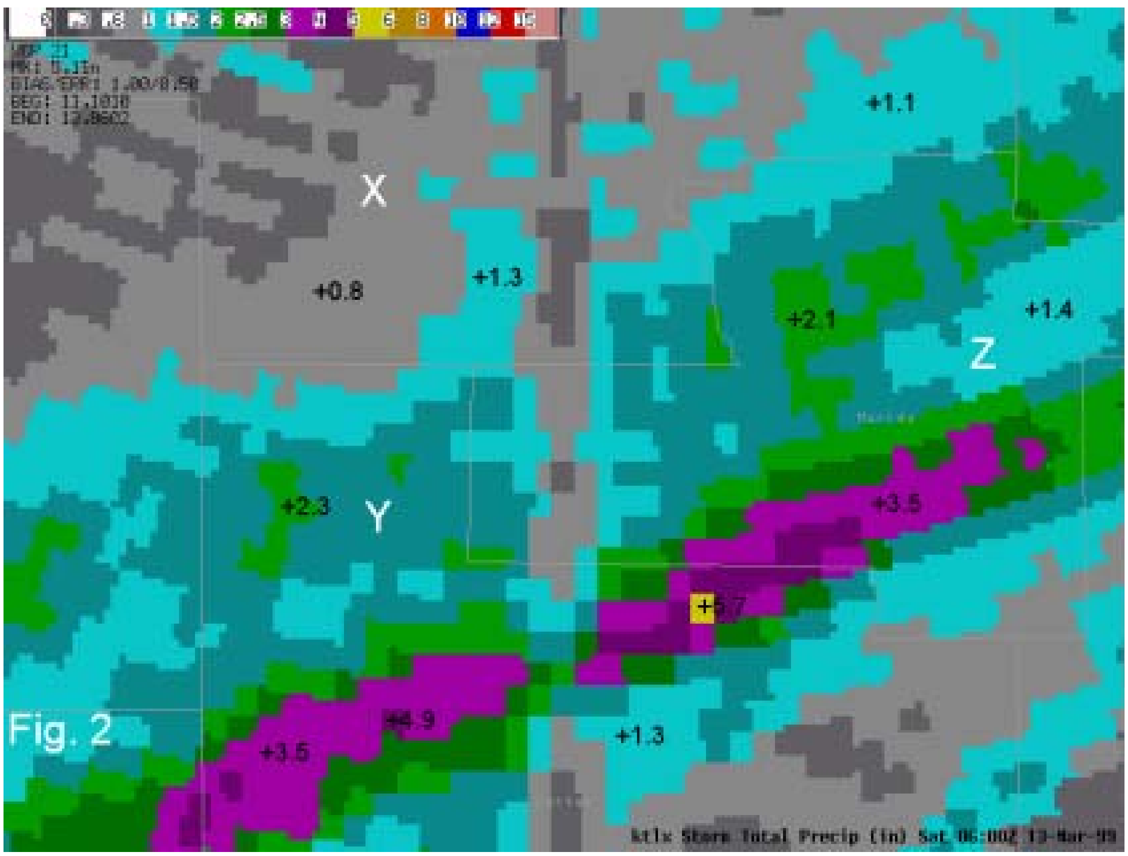
For questions 19 and 20, use Fig. 3 and the following 6 hour Flash Flood Guidance values.

X County	2.0 inches
Y County	2.5 inches
Z County	2.2 inches

19. Using the STP as a "first look", ________________county would be the HIGHEST priority for further investigation of flash flooding.

20. Which counties, if any, would also require further investigation or monitoring?


X
+2.7
+3.2
+4.1
+3.8
+4.8
+3.6
+3.9
Z
Y
+2.2
+1.9
Fig. 1
ktlx Storm Total Precip (in) Sat 06:00Z 13-Mar-99


+1.1
X
+0.8
+1.3
+2.1
+1.4
Z
+3.5
+2.3
Y
+5.7
+4.9
+3.5
+1.3
Fig. 2
ktlx Storm Total Precip (in) Sat 06:00Z 13-Mar-99

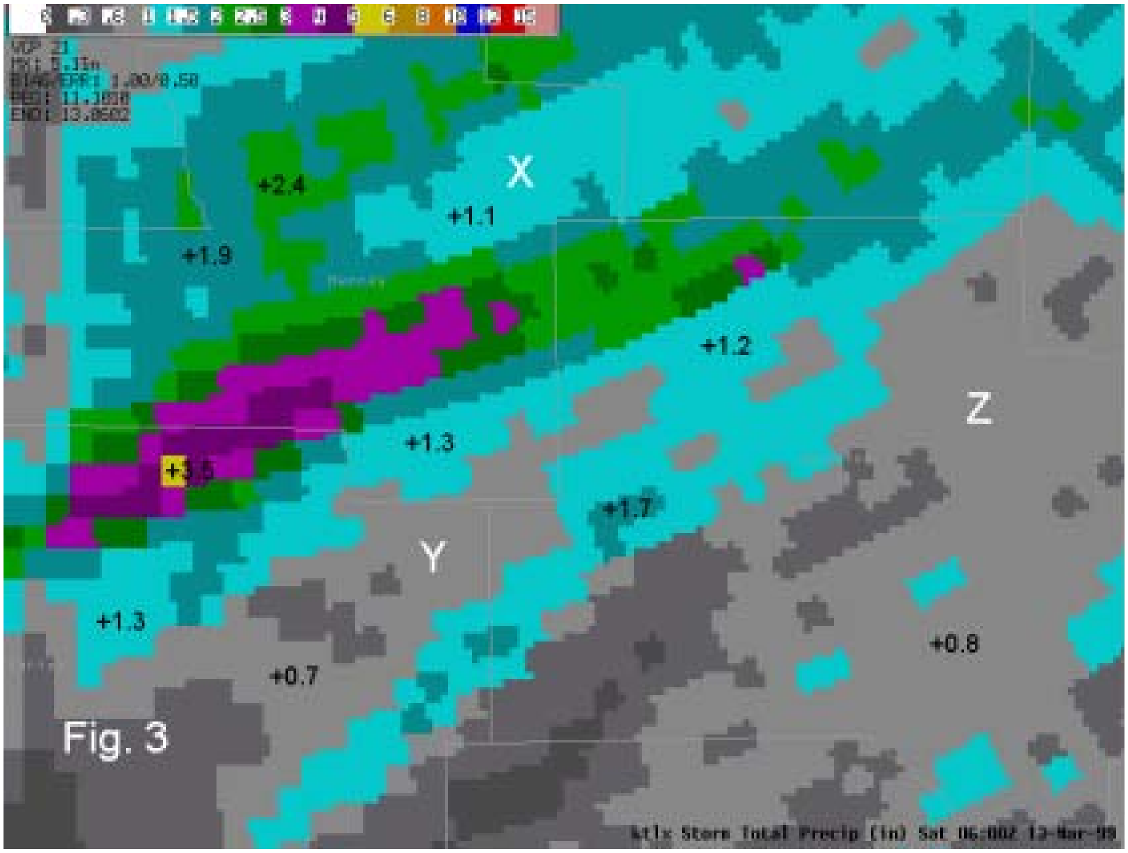

X
+2.4
+1.1
+1.9
+1.2
Z
+1.3
+1.7
Y
+1.3
+0.8
+0.7
ktlx Storm Total Precip (in) Sat 06:00Z 13-Mar-99

Fig. 3

Answer Key: Precipitation Products and Algorithms Review Exercise

Match the Product on the right to the Product Characteristic on the left. (Some characteristics will describe more than one product, thus more than one letter may be used).

1. C,D,E,F Resolution 1.1nm x 1 degree
2. A,B Resolution 0.54nm x 1 degree
3. A,B,C,E,G,H Updated each volume scan
4. D,F,H Updated at the top of the hour
5. B,C,D,E,F 16 Data levels
6. A,G 256 Data levels
7. H Available as an alphanumeric product only
8. G Not displayable at WFO AWIPS workstation
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14. T The Precipitation Processing Subsystem algorithms contain significant quality control steps.

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For questions 16 and 17, use Fig. 1.

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(D.) Y...unreliable...evidence of underestimation.

17. Rain occurred shortly after Flash Flood Guidance issuance time. The rain event that you see in Figure 1 occurred much later in the day, after a period of clear air (category 0). Thus the Flash Flood Guidance was invalid for the duration of this event. Which of the above counties would be the HIGHEST priority for further investigation?

Z County

For question 18, use Fig. 2 and 6 hour Flash Flood Guidance 4.9 inches for all counties.

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For questions 19 and 20, use Fig. 3 and the following 6 hour Flash Flood Guidance values.

X County	2.0 inches
Y County	2.5 inches
Z County	2.2 inches

19. Using the STP as a “first look”, ___Y_____ county would be the HIGHEST priority for further investigation of flash flooding.

20. Which counties, if any, would also require further investigation or monitoring?

X County

8/03

SUMMARY
OF
LIMITATIONS/STRENGTHS/APPLICATIONS

(These are from those found in the student guide and are provided here for your convenience.)

I. SCIT Products

Storm Track Information Product (STI)

Limitations

1. Errors may occur in the identification of cells and the calculation of cell attributes when cells are in close proximity.
2. Large errors may occur in the attributes of cells close to the RDA, especially in VCP 21.
   Discussion: Recall that there are large gaps between elevation angles at higher slices in VCP 21. Calculations of Cell-based VIL, Cell Base, Cell Top, Height of Maximum Reflectivity, etc. can all be adversely affected by what the radar is **not** sampling in these gaps.
3. Unrepresentative movements are possible due to propagational effects.
   Discussion: Due to development or dissipation, the high reflectivity cores change location within an identified cell from one volume scan to the next, resulting in false representation of the movement of the cell.
4. Forecast positions of curving cells are displayed as a straight line.
   Discussion: Since position forecasts are always in a straight line, the past tracks of a cell should be taken into account when using the position forecast of a curving cell.

Strengths and Applications

1. The product works best with well-defined widely separated cells.
   Discussion: Forecast positions in this case can be used in the timing of storms in warnings and nowcasts. Keep in mind that the forecast position is that of the centroid, and that adjustments should be made if the user is trying to time the leading edge of the echo or the location of a tornadic circulation.
2. A large number of past tracks, and/or four forecast positions signifies a more reliable cell movement.
   Discussion: Uneven spacing between past tracks, fewer than four forecast positions, and/or re-identification of cells indicate less reliable forecast positions.
3. The STI product is useful as an overlay on volume products, but not limited to volume products.
   Discussion: Because the product and overlay are produced at the end of the volume scan, it makes it more convenient to display on top of other volume products such as VIL and CR.
4. Cell motion is used in Storm Relative Velocity products (SRM, SRR)
   Discussion: This is what allows us to quickly view a storm relative velocity product to check for circulations. Note that any errors made in the tracking process will also be passed along to the storm relative products.
5. Cell attributes are critical inputs to the Hail Index product and SCAN.
   Discussion: Proper cell identification will improve the value of both the Hail Index Product and the Cell Trends Display.

Hail Index Product (HI)

Limitations

1. The Hail Detection Algorithm needs as input, accurate and timely measurements of the MSL altitudes for the 0^0 C and -20^0 C levels.
   Discussion: Failure to update this information will degrade the algorithm's performance. Operators will

also want to note this information on products which they get via dial-out.

2. Values of POH, POSH, and MEHS will fluctuate at close ranges, especially in VCP 21, due to gaps in coverage at higher elevation slices.
   Discussion: As a cell 50,000 feet at 80 nm moves toward the radar, the 6 degree elevation slice samples the storm at lower altitudes. Therefore POH, POSH, and MEHS would all lower. As the same cell starts moves to less than 50 nm from the radar the 9.9 degree slice begins to sample the cell at 50,000 feet, and the POH, POSH, MEHS suddenly jump not because the cell has changed, just due to how the cell is being sampled.
3. The values for POH, POSH, and MEHS may fluctuate at longer ranges from the radar due to the limited number of slices through the cell.
   Discussion: The altitude is calculated using the center-point of the beam. There can be over 10,000 feet difference in the center-points on adjacent slices at ranges over 90 nm. This can cause estimates to change erratically.
4. For cells beyond 124 nm, hail will be identified as UNKNOWN.
   Discussion: UNKNOWN is considered a lower priority than zero in attribute tables. This means a severe cell at greater than 124nm from the radar may be listed after an insignificant storm within 124nm of the radar on the Hail Attribute Table and the Composite Reflectivity Combined Attribute Table.
5. POSH and **MEHS** have tended to overestimate the chances and size of hail in weak wind and tropical environments.
   Discussion: The accuracy of the hail estimates partially depends upon the accuracy of cell (component) information. **MEHS** is an estimation of the largest hail in the cell, and often times, most of the hail from a cell is smaller. The operator has to keep in mind that the MEHS should only be used as a guide. Storm spotters and other operational means should be integrated into the warning decision.

Strengths and Applications

1. The Hail Detection Algorithm has shown a very high probability of detection in cells that contain severe hail, especially greater than one inch diameter hail.
   Discussion: A **POSH** of 50% or greater has shown great skill (CSI) as a warning threshold.

System For Convective Analysis and Nowcasting (SCAN)

Limitations

1. Limitations of algorithms used as input to SCAN must be considered.
   Discussion: For example, height attributes of cells such base, top, height of maximum reflectivity, etc. can be adversely affected by gaps between elevation slices (especially in VCP 21). In some cases a trend decreasing cell depth may be displayed, when in fact the cell is increasing in depth.
2. SCAN output is not available as early as derived products.
   Discussion: SCAN may take over a minute longer to process and display data from the radar products used as input (such as, Storm Track Information, Combined Reflectivity, VIL, Mesocyclone, and Tornadic Vortex signature).
3. For optimal use, considerable local configuration of SCAN Tables, Graphics, and Alarms is required.

Strengths and Applications

1. A large amount of information on an individual cell is displayed on a single easy-to-interpret display.
2. For well tracked cells that are greater than 20 nm from the RDA, trends of cell attributes can provide a reasonably accurate view of cell evolution.
3. If properly configured, rate of change alarms can alert operator to the need for further investigation or provide safety net.

II. Reflectivity Derived Products

Vertically Integrated Liquid (VIL)

Limitations

1. VIL values are biased by drop size.
   Discussion: Recall that the VIL equation uses Z (reflectivity), and that Z $=nD^6$ where D is the drop size (from the radar equation).
2. Threshold values are airmass dependant. Therefore values for warnings will change seasonally, may change daily, or even across the warning area.
   Discussion: Different airmasses will require different warning thresholds!
3. Values within 20 nm of radar are underestimated.
   Discussion: Storms moving into the cone of silence will appear to diminish as less and less of the storm is sampled. They will then appear to strengthen as they move out.
4. Grid VIL values will differ from Cell-Based VIL values.
   Discussion: Grid VIL values (which is what the VIL product is displaying) are derived for each 2.2 x 2.2 nm grid box where there is any data at any elevation, regardless of whether or not a “cell” has been identified by the SCIT algorithm. On the other hand, Cell-Based VILs require a storm cell to be identified first. Then using the components included in this cell definition, a single VIL for that storm cell is calculated.
5. VIL values for a strongly tilted or a fast moving storm will be **lower** than if the storm was vertical or moving slower.
   Discussion: In this case, the upper portion of the storm may extend into another grid box. It is here that a Cell-Based VIL may be more useful.
6. May be contaminated by non-precipitation echoes.
   Discussion: If non-precipitation echoes or AP returns exist, they will end up in the reflectivity data, which in turn will cause these data to be used in the VIL calculation.
7. Less VIL fluctuation with VCP 11 than VCP 21.
   Discussion: There are fewer gaps in VCP 11, mainly within 60 nm of the radar. Forecasters should keep this in mind when using any one volume scan to infer a trend, especially in VCP 21.
8. Values at distant ranges (> 110 nm) are occasionally **unreliable.**
   Discussion: In the VIL calculation, the reflectivity value at 0.5^0 is integrated down to the ground. At distant ranges the beam may be cutting through the highly reflective hail cores in the mid levels of a storm, producing an overestimation of VIL. Or, in smaller storms the beam may be overshooting the core entirely, resulting in an underestimation.

Strengths and Applications

1. Locate most significant storms.
   Discussion: This is especially helpful with significant amounts of echo on the screen. The VIL can help a forecaster know which storm to investigate first, which is extremely important in a data-rich, time-critical situation (such as in a warning environment).
2. Useful for distinguishing storms with large hail once threshold values have been established.
   Discussion: Once a threshold is established (by incorporating ground truth), forecasters can infer that storms in the same environment will likely have the same thresholds. Issues regarding the impacts of sampling should always be considered, however.
3. Persistent high VIL values are often associated with supercells.
   Discussion: Supercells with extensive reflectivity cores will exhibit relatively large VILs (considerably larger than the “warning threshold”). Keep in mind that this will not be the case for mini supercells, or LP supercells.
4. Rapid decrease in VIL values may signify onset of wind damage.
   Discussion: This is similar to the collapse of the storm top and the correlation of this with wind damage. However, you should use caution with this technique. Sampling considerations, especially in VCP 21 close to the radar, or the impact of the cone of silence in any VCP, may cause an apparent, but not actual, drop in VIL.

Reflectivity Cross Section (RCS)

Limitations

1. Cross section placement may hamper evaluation of storm structure.
   Discussion: Depending on the cross section placement, different aspects of the storm can be evaluated.
2. Echo tops and bases are truncated with no vertical extrapolation on the highest or lowest elevation angles.
   Discussion: This will be more of a problem in VCP 21 close to the radar since there are more gaps to be interpolated across. In addition, echo tops which actually terminate between beam center points on successive elevation angles will be underestimated. Bases on storms at distant ranges will be overestimated due to the effects of earth's curvature on sampling.
3. Height vs. range exaggeration.
   Discussion: This has always been the case, with even the RHI presentation. This is because the vertical extent of the product is 70,000 ft, while the maximum range is 124 nm.
4. Small features may be enlarged or missed due to interpolation.
   Discussion: Depending on where the elevation slices cut the storm, you could over exaggerate a reflectivity core, or totally miss a BWER. Once again, this will present more of a problem in VCP 21 within around 60 nm of the RDA due to more gaps.
5. Presentation of product dependent upon VCP.
   Discussion: Generally the product will be more coarse and blocky looking with VCP 21 than VCP 11. Once again, this is due to more gaps within 60 nm of the radar in VCP 21.
6. Fast moving storms may appear to be strongly tilted.
   Discussion: What appears to be an echo overhang in this cross section may actually be an artifact of VCP sampling on a fast moving storm. This is due to the time needed to complete a volume scan and the fact that the storm doesn't hold still during that time. Once again, a little more impact with VCP 21 which takes a minute longer.

Strengths and Applications

1. Detect the vertical extent of clouds/insects/smoke plumes.
   Discussion: Regardless of the phenomenon being sampled, the depth or vertical extent can be estimated with a cross section.
2. Verify existence of a bright band.
   Discussion: The bright band, a representation of the freezing/melting layer, is depicted on a Base Reflectivity product as a ring of higher reflectivities. On a cross section, it will appear as a band of higher reflectivities.
3. Estimate height of higher dBZ's.
   Discussion: Placement is critical when attempting to estimate dBZ heights. Using the VIL ,Composite Reflectivity, or a 4panel Reflectivity display may help with placement of the cross section through the reflectivity core of the storm.
4. Evaluate storm structure features.
   Discussion: Again, placement is critical in order to see features such as BWER's, WER's, and storm tilt. It may be useful to use a 4-panel reflectivity presentation with linked cursors to find a best fit line that bisects the BWER at several elevations.
5. Estimate echo tops.
   Discussion: While this product will display reflectivities down to 5 dBZ in precipitation mode, echo tops can generally be correlated with the height of the 20 dBZ returns. Using the Echo Top Product as an aid for placing the cross section line may be helpful.
6. Monitor the formation/dissipation of precipitation events.
   Discussion: This would be helpful with high based convection or with convection which initially develops aloft.

Composite Reflectivity (CR)

Limitations

1. Low level reflectivity signatures are obscured.
   Discussion: Because the algorithm uses the maximum reflectivity for each grid box from any elevation angle, many characteristic signatures will be masked. The CR product will show features, such as hook echos, at the low slice with the echo overhang attained from the higher slice. DO NOT use the CR product by itself to diagnose the presence of hook echoes, BWERs, WERs, Inflow Notches, boundaries, etc.
2. Height of reflectivity is unknown.
   Discussion: One grid box may be from 0.5^0 , while the grid box next to it may be from 10.0^0.
3. Echo aloft can't be discriminated from precipitation reaching the surface.
   Discussion: What looks like precipitation, my actually be cloud layers at 15kft! Be especially careful when using the CR product to infer the location of snow or very light rain, as much of it may in fact be aloft.
4. Non-precipitation echoes may contaminate product.
   Discussion: If Non-precipitation echoes or ground clutter are present in the Base Reflectivity data they will make their way into the CR product.

Strengths and Applications

1. Reveals highest reflectivity in all echoes.
   Discussion: This is a quick way to check which storms have the highest reflectivity present.
2. Determine storm structure features & intensity trends in storms. (When compared with base products).
   Discussion: While a CR product BY ITSELF can not be used to determine storm structure, it can be very useful when used in conjunction with other products. By displaying a 0.5^0 reflectivity product on one screen and a CR product on the other, you can (with cursors linked) assess the location and extent of the echo overhand.
3. Generate cross sections through maximum reflectivity knowing the inflow side of storm.
   Discussion: Once you see a core of 65 dBZ, you probably want to know if it's one pixel, shallow, or has great vertical extent. You can use the CR product to help place the line for the RCS and determine these attributes.
4. Combined Attribute Table is available.
   Discussion: On no other product can you display this table. It is a quick way to scan output from several algorithms without having to check through several products.

Layer Composite Reflectivity Maximum (LRM)

Limitations

1. Mid & Low layer products will use few elevation angles at long distances.
   Discussion: At long ranges where the 0.5^0 slice is at a considerable altitude, there may be only 1 or 2 slices used to compute the max value. At closer ranges, there will be data from several slices.
2. Mid and High level products are ineffective at close range due to the cone of silence.
   Discussion: There will be a hole around the radar location where the cone of silence precludes data from being used for especially the mid and high level product. That does NOT mean echo does not exist over the radar site!
3. Low layer product susceptible to non-precipitation echoes.
   Discussion: Generally speaking, the low layer is the one susceptible to ground clutter returns (anything that makes it into base reflectivity data, will make it into the LRM products). The amount of contamination will depend on the altitude used for the base of the LRM product. Often, the mid an high layer products will not have this problems except on rare occasions when the returns have significant vertical extent.

Strengths and Applications

1. Mid-High layer products can be used to estimate the height of higher reflectivities.
   Discussion: Monitoring the LRM products may assist forecasters in getting a jump on the height of

higher reflectivity cores. For instance, raising the lower layer boundary to the melting level may provide the forecaster valuable information on the height and intensity of developing pulse-type storms by using the LRM-Low product.

2. Comparison of Base Reflectivity and Mid or High Layer Composite Reflectivity Maximum product may aid in determining a storm's intensity trend.
   Discussion: If the lowest slice Base Reflectivity and the corresponding Mid layer LRM shows significant echoes in the same vicinity, you could infer that the storm is still dominated by updraft with almost all of the echo aloft. In pulse type thunderstorms, this may be the only lead time you get for warning purposes.
3. Use of the mid level product can help differentiate ground clutter from precipitation echoes.
   Discussion: Clutter which is evident on the lower slices of a Base Reflectivity, will most of the time completely disappears on the LRM-Mid Layer product. Use of the LRM-Low Layer product for this purpose would require raising the height definition to above the ground clutter.

User Selectable Layer Reflectivity Maximum (ULR)

Limitations

1. Height of data within selected layer is unavailable.
2. Shallow layers will often have concentric circles (stepped appearance) due to sampling (limited elevation angles through layer).

Strengths and Applications

1. Layer can be selected to meet user needs.
2. Has higher resolution and more data levels than LRM products.
3. Can be used to locate bright band.

LRM - Anomalous Propagation Removed (APR)

Limitations

1. The product can be misleading if traditional clutter filtering is not applied or is ineffective.
   Discussion: Residual clutter can still contaminate the product. Unsuspecting users may assume all data displayed on the product is precipitation echo since the product name indicates AP has been removed.
2. The algorithm assumes all low level data within 45km of the RDA is clutter.
   Discussion: This may result in valid data being removed in the vicinity of the RDA. Current adaptable parameter settings may not be optimal. Further testing may be needed to enhance algorithm performance.

Strengths and Applications

1. The algorithm attempts to distinguish weather targets from clutter targets.
   Discussion: Especially when traditional clutter filtering is invoked and effective, the product gives a good depiction of weather targets.

Echo Tops (ET)

Limitations

1. A circular stair-stepped appearance will often be evident due to use of beam centerline.
   Discussion: Because of the sampling technique used to interrogate the atmosphere (that of VCPs), a feature sampled at a particular range will only be displayed at the altitude of one particular elevation angle. While the actual echo probably increases and decreases gradually in altitude with range, each grid point will be assigned only a beam center point altitude. This means that two adjacent bins, that may be sampled by 2 different elevation angles, will be portrayed at very different altitudes.
2. No upward extrapolation from the last elevation angle where precipitation was detected.
   Discussion: Echos that actually end somewhere between elevation angles will be affected. They will be underestimated as the top is truncated to the last angle echo was detected. As with many volume products, this will be more of a problem in VCP 21 closer to the RDA since there are more gaps.
3. Side lobes may result in overestimated top.

Discussion: This may happen on rare occasions. Investigating the Base Reflectivity or the RCS product may help.
4. Tops will be underestimated close to the radar due to the cone of silence.
Discussion: A time lapse of the ET product showing a storm approaching the radar will indicate the tops decreasing as they approach the cone of silence, and then increasing as they move away.
5. Difficult to locate the highest echo top in a storm due to lack of upward vertical extrapolation, and heights are displayed in 5000 ft increments.
Discussion: It is therefore prudent to keep in mind that these are estimates of the Echo Top.

Strengths and Applications
1. Quick estimation of the most intense convection; higher echo tops.
Discussion: When time management is critical, this product may help you know which storms to investigate first (similar to how the VIL assists in this endeavor).
2. Assist in differentiating non-precipitation echoes from real storms.
Discussion: Most of the time AP has very little vertical extent.
3. Aids in identification of storm structure features such as tilt, updraft flank, max top over strong low level reflectivity gradient, etc.
Discussion: Another good User Function to have is a 4panel using 3 elevations of Base Reflectivity and the ET product in the fourth quadrant. You can still use proven techniques (such as the Lemon Technique) to help assess storm structure and severity.
4. May detect mid-level echoes before low-level echoes are detected.
Discussion: This is especially beneficial when echo cores primarily develop aloft. In pulse thunderstorm situations, there may be only one or two volume scans where the core remains aloft before descending to the surface. This product may enable you to get positive lead time on a warning for such a storm.

III. Velocity Derived Products

Storm-Relative Mean Radial Velocity Map (SRM)
Limitations
1. Storm-relative flow will be inaccurate if the storm motion subtracted isn't representative of the storm being investigated.
Discussion: There are a couple of instances in which you should keep this in mind. The first is when the SCIT algorithm is not tracking anything well. Recall limitations in the SCIT algorithm which can lead to erroneous storm motions. If this motion is significantly in error, actual features may be totally obscured in the SRM product. The second, is when the SCIT algorithm is actually doing very well but the storms are moving in different directions. When the average of these storms is taken, the resultant motion may be non-representative of any one storm. In these cases, the user should override the default motion and input one of their own.
2. More difficult to determine actual ground-relative winds.
Discussion: If you want to estimate the impact of the gust front as it slams into your office, you don’t want to subtract out that storm motion.
3. Average storm-relative motion likely will vary from volume scan to volume scan.
Discussion: SCIT computes the average storm motion each volume scan. Therefore when strong rotation on one scan appears not as strong on the next scan, it may really be due to a change in the average storm motion used.

Strengths and Applications
1. Used to investigate the 3-D velocity structure of a storm when used in a 4 panel.
Discussion: Remember to have *at least* 4 elevations of SRM (same elevations as were chosen for Base Reflectivity) on your RPS List. You will want to sample the lowest, middle and top portions of the

storm in your 4-panel presentation. Keep in mind how range and VCP issues may minimize or optimize your ability to sample the storm at these locations.
2. Most useful with faster moving storms (> 10 kts).
Discussion: If you can’t identify a rotational signature, you may not even consider warning for it.. Subtracting out the storm motion is like viewing the storm as if it were standing still, thereby allowing the rotation signature to stand out.
3. Operator may input storm motion at AWIPS.
Discussion: If you don’t like the default, input your own motion and make a one time request.

8-Bit Storm-Relative Mean Radial Velocity Map

Limitations
1. The 8-bit Base Velocity products used by AWIPS to produce the 8-bit SRM are large and can produce narrowband loadshedding unless a LAN-to-LAN connection is used.
2. Cannot do image pairing with reflectivity products and maintain resolution on the AWIPS HP workstations (LINUX workstations are OK with the use of procedures).
3. Suitable color tables need to be developed.
4. RPS list size restrictions may limit availability of needed 8-bit Base Velocity products to produce 8-bit SRM.
5. Care must be taken to ensure a representative storm motion is being produced by the default motion setting chosen.

Strengths/ Applications
1. High detail both spatially and data magnitude can provide improved detection of TVSs, Mesocyclones, Microbursts, Boundaries.
2. Same data levels and color scales can be used for both Clear Air Mode and Precipitation Mode VCPs.
3. High Storm Relative Velocities (up to 248 kts) are displayable and viewable on cursor readout sampling.

Storm-Relative Mean Radial Velocity Region (SRR)

Limitations
1. Storm-relative flow will be inaccurate if storm motion used isn't representative of storm being investigated.
Discussion: The same considerations that applied to SRM also apply to SRR.
2. Difficult to determine ground-relative winds.
Discussion: As with the SRM, you don’t want to use the SRR to determine ground relative winds. A Base Velocity product would be more appropriate.
3. Limited viewing area.
Discussion: The limited viewing area makes it inappropriate to put this product on the RPS List (in most instances).
4. Data levels are fixed.

Strengths and Applications
1.Better resolution and less chance for storm-relative error on the SRR than on the 4-bit SRM product.
Discussion: The resolution of the SRR is .27 nm and uses only one storm motion as default, versus .54 nm resolution and the average of all storms with SRM.
2. Aids in displaying: shear and rotation in storms, and storm top divergence.
Discussion: The value of the SRR product (like the SRM product) is to isolate shears and rotation on fast-moving (especially) storms.
3. Operator may input storm motion at AWIPS.
Discussion: As with the SRM, you may override the default if you choose with a motion of your own. On especially significant storms, you may choose to do this at several elevation angles for the most

accurate representation.

4. Displayed max inbound/outbound velocities are valid within window.
   Discussion: This can be especially helpful if the velocities in the signature of interest exceed 50kts. Since the max values only apply to the window, you can better ascertain the actual velocities.
5. Useful as an alert-paired product with MESO/TVS alerts.

Velocity Cross Section (VCS)

Limitations

1. Doppler velocities are relative to the RDA.
   Discussion: As stressed in Velocity Interpretation, you must always know where the phenomenon is in relation to the RDA. It is recommended that you display the Current Cross Section Overlay on one screen (left) and the corresponding cross section on the opposite screen. Attempt to interpret a velocity cross section without knowing where the RDA is relative to it, is impossible!
2. Height exaggerated vs range.
   Discussion: With the grid used, the height can be up to 70Kft with the range up to 124nm. This is the same limitation observed in the RCS product that makes features look skinny and taller than they look out your window.
3. Interpolation may enlarge or miss features.
   Discussion: Just as with the RCS product, gaps in the VCP will result in interpolation which may smooth through or enlarge a particular feature.
4. Storm-relative cross section is NOT available.
   Discussion: This may make it difficult to interpret signatures in especially fast moving storms.
5. Storm top divergence estimates are limited due to radar viewing angle and data thresholds.
   Discussion: Difficult to determine hail larger than golf ball size using NSSL criteria unless both maxima listed on the top of the grid are close to the storm summit.. As always, the ability to see features with the cross section products is highly dependent upon placement of the cross section.

Strengths and Applications

1. Aid in determining storm structure features.
   Discussion: These features include:
   a. Inferring location of **updraft/downdraft interface** - as seen on a VCS taken <u>down the radial</u>.
   b. Strength of **storm top divergence** - When scanning down radial, we are looking for convergence at low levels, updraft/downdraft interface, and finally divergence at storm summit.
   c. **Depth of mesocyclones** - For this you want a VCS <u>perpendicular to the radial</u> through the mesocyclone.
2. Has proven very valuable for kinematic insights in a research setting.
   Discussion: You may have figured it out by now, but Velocity Cross Sections take some practice at interpreting. That (plus the limitations listed above) will probably limit their use during real time. They are however extremely useful for gaining insight to the kinematic workings of the thunderstorm in a research setting.

Velocity Azimuth Display (VAD)

Limitations

1. Needs sufficient data points.
   Discussion: Clear, cold, dry air often lacks scatterers. No sine wave will be plotted unless there are at least 25 data points.
2. May be unreliable in disturbed environments.
   Discussion: The algorithm assumes horizontal uniformity of the wind field. Imagine a cold front lying across the RDA. You look to the North, the winds are blowing toward the radar. You look toward the South ahead of the front, winds are also blowing toward the radar. The algorithm will have a hard time finding an “average” wind across the area under these circumstances! The wind estimate it gives you (if

indeed it gives you one at all) will NOT be very useful.

3. Available for preestablished altitudes only.
   Discussion: The altitudes are set at the ORPG HCI. If you want to see winds at any other altitudes, you must change them there (URC level of change authority).
4. Large flocks of migrating birds may produce anomalous wind data.
   Discussion: The averaging of the motion of birds in conjunction with the motion of the wind, can lead to erroneous wind data. Birds can cause the speed to be off by several knots and the direction to be off by several degrees. Typical symptoms include an "explosion" of reflectivity returns in a "butterfly" pattern centered on the RDA just after sunset.

Strengths and Applications

1. Winds available in clear air or precipitation mode.
   Discussion: Generally speaking, the wind estimates will be slightly better in clear air mode since the radar antenna rotation is slower. This may on some occasions mean you will get winds through a deeper layer as well.
2. Does not require 360 degrees of data.
   Discussion: The algorithm only requires 25 data points (that's a sample from 25 degrees of azimuth) and they don't have to be contiguous. The "Beginning" and "Ending" azimuth range is set at the ORPG HCI and is under URC level of change authority.
3. Check missing or suspicious wind data on the VWP.
   Discussion: This is probably the primary reason many operators choose to look at the VAD. When you see "ND" plotted on the VAD Wind Profile, you can go the VAD at that altitude and see what happened.
4. Update Environmental Winds Table.
   Discussion: The VAD winds are fed into the Environmental Winds Table for use in the velocity dealiasing algorithm. This helps minimize erroneous winds due to dealiasing failures.
5. VAD winds included on the Radar Coded Message (RCM).

VAD Wind Profile (VWP)

Limitations

1. Measurable returns needed - for each altitude, at least 25 data points are required on the VAD for a sine wave to be plotted. If one is not plotted, the wind will not be calculated at that altitude.
   Discussion: In what instance might you think scatterers would be few and far between? Generally, the dryer and more pristine the atmosphere, the fewer the number of scatterers. This would likely occur with the intrusion of a clear, dry arctic airmass. In addition very high altitudes which are free of clouds will seldom have enough scatterers to produce reflectivity return.
2. Winds are not encoded if RMS error or symmetry thresholds are exceeded.
   Discussion: If the points don't fit the sine curve well enough (RMS exceeds 9.7 kts), or if the winds are too convergent or divergent across the RDA (symmetry exceeds 13.6 kts), then "ND" will be plotted at that altitude of the VWP.
3. Generally only representative of winds within 20 nm of the RDA.
   Discussion: This is a wind estimate, averaged around 360^0 of the RDA. It is attempted to be taken at the same range (default slant range) at all elevations. While this gives a good estimate of a "profile" of the winds at the surface and aloft near the RDA, it tells you nothing about winds at much further ranges.
4. Difficult to read wind barbs when north wind barbs and south wind barbs are on successive altitudes.
   Discussion: When winds are due north or due south at adjacent altitudes, the barbs may tend to overwrite each other. Use of the Filter or Blink Functions may help.
5. Birds can produce anomalous wind patterns.
   Discussion: The usual scenario is an "explosion" of reflectivity coverage and strength as night migrating birds take off. Experts claim that a single Sea Gull can be detected at a range of 460 km. If it is critical to determine the true upper winds, the site should take a supplemental balloon sounding.

Strengths and Applications

1. The VAD Wind Profile (VWP) may be of assistance in forecast and warning operations.
   Discussion: **Severe Weather** operations may benefit as backing or veering of the winds with time display changes in the environment.
   Aviation operations will be assisted by evidence of wind shear. Low level wind shear may be more visible on VWP than Profilers. **Hydrology** and **Forecasting** may benefit from indications of the change in the depth of cold air with time, etc. In addition, since sufficient scatterers are often more prevalent in and near clouds, the VWP may be used in estimating cloud tops and bases, and the change of those bases and tops as the cloud layer approaches or recedes.
2. The VWP can be used to create/adjust hodographs.
   Discussion: Remember to use the VWP of the radar whose environment most closely resembles that of the storms being sampled.
3. Future development may include combining the Storm Tracking Algorithm and VAD Wind Profile to output helicity.
   Discussion: The integration of data sets into one workstation will allow for this and other applications to be developed.

Mesocyclone(M)

Limitations

1. Time continuity is not employed.
   Discussion: The algorithm does not wait for 2 volume scans. If it is identified on one volume scan, it is classified as a Mesocyclone. This means that transient shears can identified on one volume scan, and then lost on the next. Recall that for an "operator" identified mesocyclone, you would most of the time want some kind of time continuity to establish validity.
2. Does not need 10,000 ft deep circulation.
   Discussion: The algorithm only requires 2 vertically linked elevation angles. If the feature is very close to the radar, the vertical depth provided by two adjacent slices may be only 1Kft. Shears along boundaries close to the RDA will often trigger detections because of this.
3. The algorithm only detects cyclonic rotations.
   Discussion: Because the algorithm looks for "increasing" velocity values when defining pattern vectors, an anticyclonic circulation (where velocity values decrease azimuthally) would not pass the test.
4. Identification is influenced by aspect ratio.
   Discussion: Since the beam gets broader with range, large features will be harder to resolve and small features may be missed entirely. You should always consider the effects of sampling on the algorithm's ability to detect features and use a closer radar if possible.
5. Don't know which elevation angle to examine shear.
   Discussion: The Attribute Table and Mesocyclone Alphanumeric Product only give height of the feature. Can you say right off what elevation angle you need to look at in order to validate a particular height? You would likely have to refer to a range/height diagram to see what slice you need to look at.
6. Range thresholds may discard or improperly classify mesocyclones.
   Discussion: Because of the MAX HGT MESO value, NO mesocyclones will be identified beyond about 110nm. This is because the algorithm will ignore anything above 26Kft. Beyond 110nm, the 1.5 degree slice is at this altitude. It will therefore be ignored. As a result, the best you can do beyond this range is Uncorrelated Shear. In addition, within about 5nm of the RDA, the velocity information will also be ignored.
7. Improper dealiasing may generate false mesocyclones.
   Discussion: You will need to examine velocity data to see what the input into the algorithm was.
8. Algorithm default values adapted for "classic" supercells.
   Discussion: Modifications to adaptable parameters (pattern vectors, for instance) will help to customize this algorithm for your area or for a particular environment.

Strengths and Applications

1. Identify mesocyclones.

Discussion: The algorithm does a good job in analyzing all velocity information at every slice in the volume scan to give you a good first look at possible significant circulation. The operator must then incorporate reflectivity, SRM, as well as other sources of input to verify the existence of mesocyclones.

2. A mid-level mesocyclone that lowers toward the surface may indicate a tornado is developing.

Discussion: A mesocyclone the develops in the mid levels, and then begins to descend and strengthen with time can be indicative of imminent tornadic activity. You can monitor the base of the mesocyclone in the attribute table (or in the alphanumeric product) to help diagnose this.

Mesocyclone Rapid Update (MRU)

Limitations

1. Classification as *Increasing* or *Persistent* may be the result of sampling issues versus a change in the actual attributes of the feature.

Discussion: A change from 3DC to Meso (and vice versa) can merely be the result of improved (or lesser) symmetry calculations.

2. The MRU graphical attribute table and alphanumeric attribute table contain attributes from both previous and current volume scan information.

3. Feature matching ability dependant on motion supplied by SCIT algorithm.

Discussion: Incorrect storm motion will result in improper or no matching.

Strengths and Applications

1. Intermediate algorithm output is available before the end of the volume scan.
2. MRU tracks features to develop time continuity.

Tornadic Vortex Signature (TVS)

Limitations

1. Adaptable parameters need more research.

Discussion: Parameters which work well in one type of meteorological setting may not be as effective in other situations. More research on the results of various adaptable parameter settings is also needed.

2. High false alarm rates especially in squall lines and tropical cyclones.

Discussion: A high FAR with TDA may result in over-warning, or desensitizing forecasters.

3. Little research has been done to date relating the occurrence of tornadoes to Elevated TVSs.

Discussion: Forecasters should use ETVS output with caution until they develop a better understanding of its utility.

Strengths and Applications

1. Algorithm searches for gate-to-gate shears.

Discussion: The definition of an operator defined TVS is based on gate-to-gate shear associated with tornadic circulations. The algorithm attempts to follow this definition.

2. Multiple velocity-difference thresholds make it possible to isolate small regions of shear within broader regions

Discussion: In areas of broad shear, such as along a squall line, the higher velocity thresholds help to identify small scale circulations within high-shear zones, such as what you would find along the comma-head in a bow echo.

3. A distinction is made between different types of shears.

Discussion: Information depicted about each feature includes whether or not it is a TVS or an ETVS as well as the relative strength and vertical depth of the feature. This information can be operationally significant when attempting to rank and sort through identified features.

4. Adaptable parameters allow for fine tuning of algorithm output.

Discussion: Through a number of parameter sets as well as individual adaptable parameters, operators can fine tune the output for their location and environment, as well as operator preference. As a result, it is more likely that operationally significant shear regions will be detected.

IV. Precipitation Algorithms and Products

Precipitation Processing Subsystem

Limitations

1. Algorithms do not account for:
   a) below beam effects (wind, evaporation, or coalescence
   b) non-uniform z/r relationships within the radar coverage area
2. Algorithms do not always account for:
   a) bright band contamination
   b) hail contamination
   c) inaccuracies due to radar outages

Strengths and Applications

1. They are the only source of real time high resolution rainfall accumulations.
2. Algorithms us significant quality controls designed to produce better products by:
   a) minimizing overestimation from ground clutter caused by anomalous propagation
   b) eliminating reflectivity outliers and spurious noise
   c) reducing the effects of beam blockage

One Hour Precipitation (OHP)

Limitations

1. After extended outages, the first product will not be generated for 54 minutes.
2. For some events, viewing interval is too short.

Strengths and Applications

1. Assess rainfall accumulations for flash flood watches, warnings, and statements
2. Nowcasts and special weather statements
3. Time lapse can provide storm movement
4. Other water management applications

Three Hour Precipitation (THP)

Limitations

1. The product updated only once per hour.

Strengths and Applications

1. The THP provides a longer viewing interval.
2. For very long duration events, it can be used with Storm Total Product for analysis.
3. The three-hour interval corresponds to timing of flash flood guidance values.

Storm Total Precipitation (STP)

Limitations

1. At some sites, the system can stay in category 1 or 2 for extended periods of time (can not manually reset to zero).
2. The product could include missing data without the knowledge of the operator.

Strengths and Applications

1. The product can be used to monitor total precipitation accumulation.
2. It provides a good estimate of ground saturation and/or total basin runoff.
3. The product is very useful for post storm analysis.
4. When used in a time lapse, it is useful for tracking the motion of storms.

User Selectable Precipitation (USP)

Limitations

1. USP accumulations are updated only at the top of the hour.
2. The product may contain missing data. At least two thirds of the specified hourly accumulations must be available for product generation.
3. Since the USP is a customized product, only 10 can be generated per volume scan.

Strengths and Applications

1. The product provides a flexible time interval to meet varying weather situations.
2. In addition to the 24 hour default USP, any others generated for associated users are available as a one-time request to non-associated users.

Hybrid Scan Reflectivity(HSR)

Limitations

1. The tilt test may eliminate valid returns at 0.5^0.
2. Bi-Scan Maximization may increase negative impact of bright band contamination.

Strengths and Applications

1. View reflectivity used for precipitation products.
2. Assess the accuracy of the precipitation products.
3. Quickly search for inconsistencies in the data.
4. Assist operator in discriminating between precipitation returns and ground returns due to anomalous propagation.

Digital Hybrid Scan Reflectivity(DHR)

Limitations

1. Large product size

Strengths and Applications

1. High resolution (256 data levels) allows for innovative color tables.
2. High accuracy (0.5 dBZ)
3. Used in the generation of external products.
   -Flash flood Monitoring and Predicition (FFMP)
   - Jendrowski Scripts (multiple Z/R AWIPS Application)
   - Areal Mean Basis Estimated Rainfall (AMBER)